Topic 5.3 Bond Enthalpy

Past Exam Questions (Paper 1, 2)

1. *[1 mark]*

Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

Bond	Bond energy / kJ mol^{-1}
H–H	440
I–I	150
H–I	300

A. +290

B. +10

C. –10

D. –290

2. *[1 mark]*

Which process represents the C–Cl bond enthalpy in tetrachloromethane?

A. $CCl_4(g) \rightarrow C(g) + 4Cl(g)$

B. $CCl_4(g) \rightarrow CCl_3(g) + Cl(g)$

C. $CCl_4(l) \rightarrow C(g) + 4Cl(g)$

D. $CCl_4(l) \rightarrow C(s) + 2Cl_2(g)$

3. *[1 mark]*

Which equation best represents the bond enthalpy of HCl?

A. $HCl(g) \rightarrow H^{+}(g) + Cl^{-}(g)$

B. $HCl(g) \rightarrow H(g) + Cl(g)$

C. $HCl(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$

D. $2HCl(g) \rightarrow H_2(g) + Cl_2(g)$

4. *[1 mark]*

Which statement about bonding is correct?

A. Bond breaking is endothermic and requires energy.

B. Bond breaking is endothermic and releases energy.

C. Bond making is exothermic and requires energy.

D. Bond making is endothermic and releases energy.

5. *[1 mark]*

Which equation represents the bond enthalpy for the H–Br bond in hydrogen bromide?

A. $HBr(g) \rightarrow H(g) + Br(g)$

B. $HBr(g) \rightarrow H(g) + Br(l)$

C. $HBr(g) \rightarrow H(g) + \frac{1}{2}Br_2(l)$

D. $HBr(g) \rightarrow H(g) + \frac{1}{2}Br_2(g)$

6. *[1 mark]*

Which processes are exothermic?

I. $CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

II. $Cl_2(g) \rightarrow 2Cl(g)$

III. $CH_3CH_2COOH(aq) + NaOH(aq) \rightarrow CH_3CH_2COONa(aq) + H_2O(l)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

7. *[1 mark]*

Which combination is correct about the energy changes during bond breaking and bond formation?

	Bond breaking	Bond formation
A.	exothermic	exothermic
B.	exothermic	endothermic
C.	endothermic	exothermic
D.	endothermic	endothermic

8. *[1 mark]*

The reaction between methane and oxygen is exothermic.

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

Which statement is correct?

A. The total bond enthalpies of the reactants are less than the total bond enthalpies of the products.

B. The total bond enthalpies of the reactants are greater than the total bond enthalpies of the products.

C. The total energy released during bond formation is less than the total energy absorbed during bond breaking.

D. The activation energy is the difference between the total bond enthalpies of the products and the total bond enthalpies of the reactants.

9. *[1 mark]*

Which equation corresponds to the bond enthalpy of the H–I bond?

A. $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$

B. $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(s)$

C. $HI(g) \rightarrow H^+(g) + I^-(g)$

D. $HI(g) \rightarrow H(g) + I(g)$

10. *[1 mark]*

Which enthalpy changes can be calculated using **only** bond enthalpy data?

I. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

II. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

III. $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. *[2 marks]*

Two students were asked to use information from the Data Booklet to calculate a value for the enthalpy of hydrogenation of ethene to form ethane.

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

John used the average bond enthalpies from Table 10. Marit used the values of enthalpies of combustion from Table 12.

Calculate the value for the enthalpy of hydrogenation of ethene obtained using the average bond enthalpies given in Section 11 of the data booklet.

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12a. *[2 marks]*

In some countries, ethanol is mixed with gasoline (petrol) to produce a fuel for cars called gasohol.

Define the term *average bond enthalpy*.

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12b. *[3 marks]*

Use the information from Table 11 of the Data Booklet to determine the standard enthalpy change for the complete combustion of ethanol.

$$CH_3CH_2OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

13. *[3 marks]*

Using bond enthalpy values, calculate ΔH^{Θ} for the following reaction.

$$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$$

14. *[3 marks]*

Ethene, C_2H_4, and hydrazine, N_2H_4, are hydrides of adjacent elements in the periodic table.

Hydrazine is a valuable rocket fuel.

The equation for the reaction between hydrazine and oxygen is given below.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

Use the bond enthalpy values from Table 10 of the Data Booklet to determine the enthalpy change for this reaction.

15. *[3 marks]*

Determine the standard enthalpy change, in $kJ\ mol^{-1}$, for the complete combustion of butan-1-ol, C_4H_9OH, using the information from Table 11 of the Data Booklet.

16. *[3 marks]*

Methanol is made in large quantities as it is used in the production of polymers and in fuels. The enthalpy of combustion of methanol can be determined theoretically or experimentally.

$$CH_3OH(l) + 1\frac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Using the information from Table 11 of the Data Booklet, determine the theoretical enthalpy of combustion of methanol.

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17a. *[2 marks]*

Propane can be formed by the hydrogenation of propene.

$$CH_3CH = CH_2(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$$

Enthalpy changes can be determined using average bond enthalpies. Define the term *average bond enthalpy*.

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17b. *[2 marks]*

Determine a value for the hydrogenation of propene using information from Table 11 of the Data Booklet.

17c. *[1 mark]*

Explain why the enthalpy of hydrogenation of propene is an exothermic process.

18. *[4 marks]*

The following equation represents a combustion reaction of propane, $C_3H_8(g)$ when the oxygen supply is limited.

$$C_3H_8(g) + 3\frac{1}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(g)$$

(i) Determine ΔH, the enthalpy change of the reaction, in $kJ\ mol^{-1}$, using average bond enthalpy data from Table 11 of the Data Booklet. The bond enthalpy for the carbon-oxygen bond in carbon monoxide, CO, is 1072 $kJ\ mol^{-1}$.

(ii) The CO molecule has dative covalent bonding. Identify a nitrogen-containing positive ion which also has this type of bonding.

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19a. *[1 mark]*

In December 2010, researchers in Sweden announced the synthesis of N,N–dinitronitramide, $N(NO_2)_3$. They speculated that this compound, more commonly called trinitramide, may have significant potential as an environmentally friendly rocket fuel oxidant.

Methanol reacts with trinitramide to form nitrogen, carbon dioxide and water. Deduce the coefficients required to balance the equation for this reaction.

$$\_\_ N(NO_2)_3(g) + \_\_ CH_3OH(l) \rightarrow \_\_ N_2(g) + \_\_ CO_2(g) + \_\_ H_2O(l)$$

19b. *[3 marks]*

Calculate the enthalpy change, in $kJ\ mol^{-1}$, when one mole of trinitramide decomposes to its elements, using bond enthalpy data from Table 11 of the Data Booklet. Assume that all the N–O bonds in this molecule have a bond enthalpy of 305 $kJ\ mol^{-1}$.

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20a. *[3 marks]*

Chlorine occurs in Group 7, the halogens.

Chloroethene, $H_2C{=}CHCl$, the monomer used in the polymerization reaction in the manufacture of the polymer poly(chloroethene), PVC, can be synthesized in the following two-stage reaction pathway.

$Stage\ 1{:}\ C_2H_4(g) + Cl_2(g) \rightarrow ClCH_2CH_2Cl(g)\ Stage\ 2{:}\ ClCH_2CH_2Cl(g) + HC = CHCl(g) + HCl(g)$

Determine the enthalpy change, ΔH, in $kJ\ mol^{-1}$, for stage 1 using average bond enthalpy data from Table 11 of the Data Booklet.

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20b. *[1 mark]*

State whether the reaction given in stage 1 is exothermic or endothermic.

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21. *[3 marks]*

The reaction between ethene and steam is used in the industrial production of ethanol.

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

The enthalpy change of the reaction can be calculated either by using average bond enthalpies or by using standard enthalpies of formation.

Determine the enthalpy change of the reaction, in $kJ\ mol^{-1}$, using the average bond enthalpies in Table 11 of the Data Booklet.

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