

Hess's Law

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Hess's Law
Booklet	Question Paper 1

Time Allowed: 76 minutes

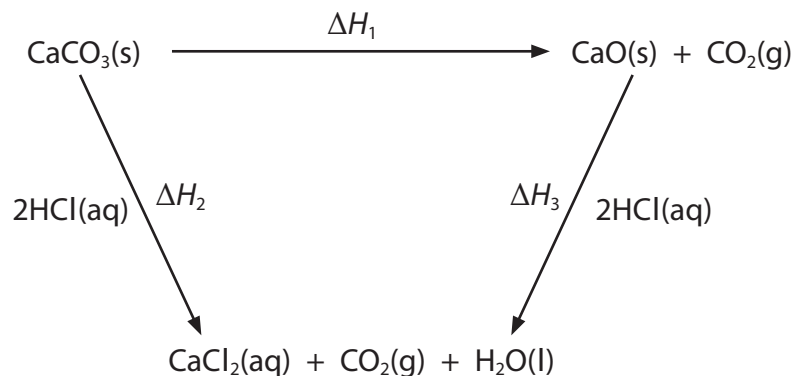
Score: /63

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

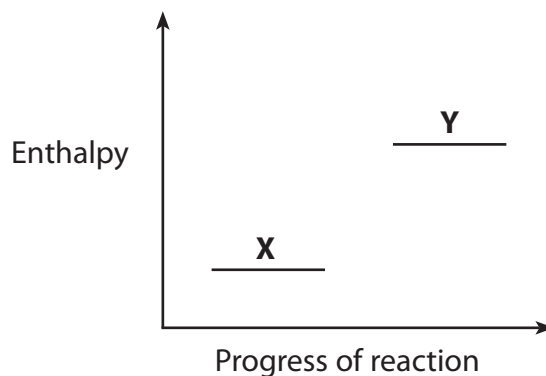
- 1 Hess's law can be used to determine enthalpy changes which cannot be measured directly, such as the thermal decomposition of calcium carbonate.



Using Hess's law, the expression to determine ΔH_1 is

- A $\Delta H_1 = \Delta H_2 - \Delta H_3$
- B $\Delta H_1 = \Delta H_2 + \Delta H_3$
- C $\Delta H_1 = 2\Delta H_2 - 2\Delta H_3$
- D $\Delta H_1 = 2\Delta H_2 + 2\Delta H_3$

- 2 An enthalpy level diagram for a reaction is



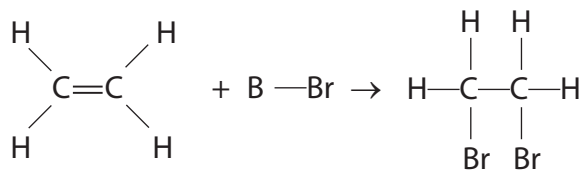
Which row in the table shows the correct terms for X and Y and the enthalpy change for this reaction?

	X	Y	Enthalpy change
<input type="checkbox"/> A	products	reactants	endothermic
<input type="checkbox"/> B	products	reactants	exothermic
<input type="checkbox"/> C	reactants	products	endothermic
<input type="checkbox"/> D	reactants	products	exothermic

3 The table shows the mean bond enthalpies for some covalent bonds.

Covalent bond	C—C	C=C	Br—Br	C—Br	C—H
Mean bond enthalpy / kJ mol ⁻¹	347	612	193	290	413

What is the approximate enthalpy change, in kJ mol⁻¹, for the reaction shown?



- A -225
- B -122
- C +122
- D +225
-

4 Some energy changes involved in a Born-Haber cycle are

- A electron affinity
- B lattice energy
- C standard enthalpy change of atomization
- D standard enthalpy change of formation

(a) Which enthalpy or energy change is represented by **p**?



- A
- B
- C
- D

(b) Which enthalpy or energy change is represented by **q**?



- A
- B
- C
- D

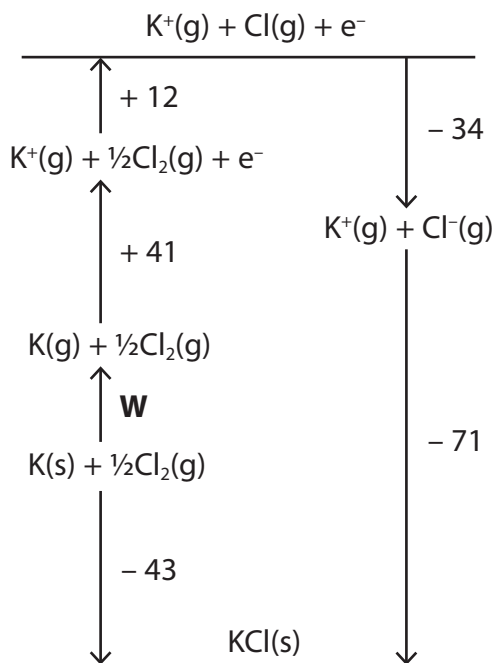
(c) Which enthalpy or energy change is represented by **r**?



- A
- B
- C
- D

(Total for Question 4 = 3 marks)

- 5 The diagram, which is not drawn to scale, shows the Born-Haber cycle for potassium chloride. The energy changes given are in kJ mol^{-1} .

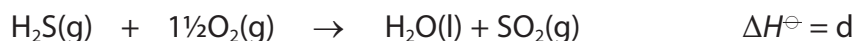
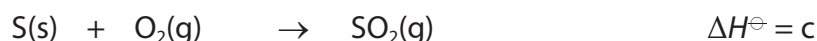
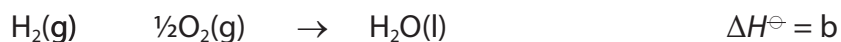
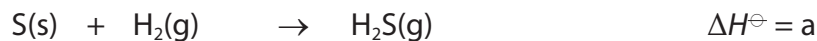


What is the value for W , in kJ mol^{-1} ?

- A -956
- B -82
- C $+82$
- D $+956$

(Total for Question 5 = 1 mark)

6 Consider the following data.

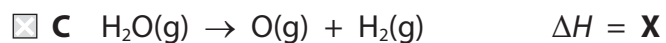
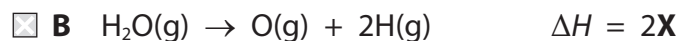
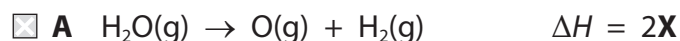


What is the relationship between a, b, c and d?

- A $a = b + c - d$
- B $a = d - b - c$
- C $a = b - c - d$
- D $a = d + c - b$

(Total for Question 6 = 1 mark)

7 In which of the following does ~~not~~ represent the mean bond enthalpy for the O–H bond in water?

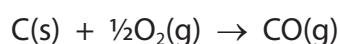


(Total for Question 7 = 1 mark)

8 Consider the following data:



Calculate the value of the enthalpy change, in kJ mol^{-1} , for the following reaction.



- A -243
- B -111
- C +111
- D +243

(Total for Question 8 = 1 mark)

9 Which of the following equations represents a step that is **not** involved in the Born-Haber cycle for lithium iodide, LiI?

- A $\text{Li(s)} + \frac{1}{2}\text{I}_2\text{(s)} \rightarrow \text{LiI(s)}$
- B $\frac{1}{2}\text{I}_2\text{(s)} \rightarrow \text{I(g)}$
- C $\text{Li(s)} \rightarrow \text{Li(g)}$
- D $\text{I(g)} \rightarrow \text{I}^+\text{(g)} + \text{e}^-$

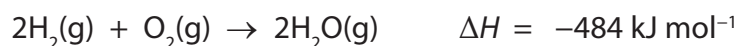
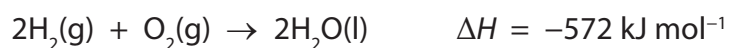
(Total for Question 9 = 1 mark)

10 Which of the following statements is true?

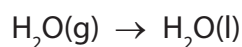
- A Breaking covalent bonds requires energy and making ionic bonds requires energy.
- B Bond breaking is endothermic whereas bond making is exothermic.
- C Bond breaking is exothermic whereas bond making is endothermic.
- D Breaking ionic bonds releases energy whereas making covalent bonds requires energy.

(Total for Question 10 = 1 mark)

11 Consider the two equations given below.



From this information, calculate the enthalpy change for the following process

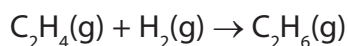


- A -44 kJ mol^{-1}
- B $+44 \text{ kJ mol}^{-1}$
- C -88 kJ mol^{-1}
- D $+88 \text{ kJ mol}^{-1}$

(Total for Question 11 = 1 mark)

- 12 The standard enthalpy change for the formation of ethene, C_2H_4 , is $+52.2 \text{ kJ mol}^{-1}$ and that of ethane, C_2H_6 , is $-84.7 \text{ kJ mol}^{-1}$.

Calculate the standard enthalpy change for the reaction below, in kJ mol^{-1} .



- A -32.5
- B -136.9
- C $+136.9$
- D This cannot be calculated using only the data above.

(Total for Question 12 = 1 mark)

- 13 Which of the following equations represents a reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H_{f,298}^{\ominus}$?

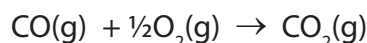
- A $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
- B $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$
- C $H_2O(g) \rightarrow H_2O(l)$
- D $H_2O(s) \rightarrow H_2O(l)$

(Total for Question 13 = 1 mark)

- 14 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
CO in carbon monoxide	+1077
O=O	+498
C=O in carbon dioxide	+805

The enthalpy change for the reaction



in units of kJ mol^{-1} is

- A -284
- B $+35$
- C $+521$
- D $+770$

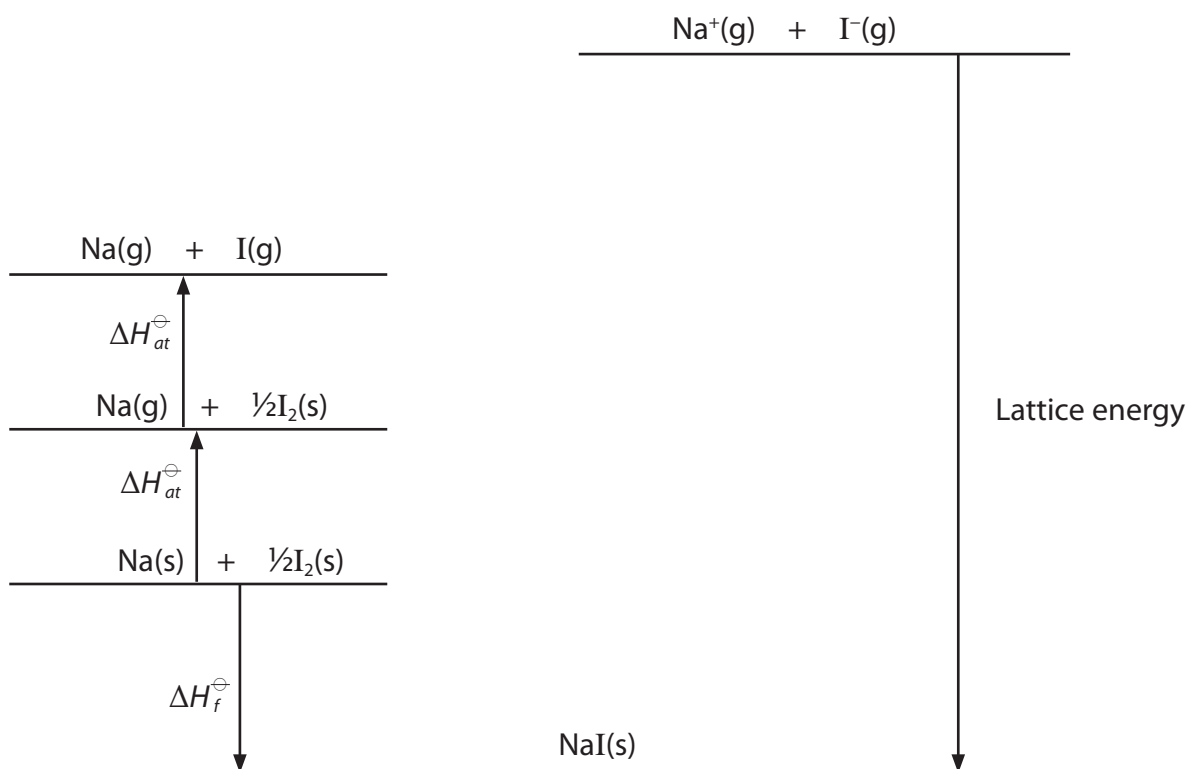
(Total for Question 14 = 1 mark)

15 The following data can be used in the Born-Haber cycle for sodium iodide, NaI.

Energy change	$\Delta H / \text{kJ mol}^{-1}$
Enthalpy change of atomisation of iodine	+107
Enthalpy change of atomisation of sodium	+107
First ionisation energy of sodium	+496
First electron affinity of iodine	-295
Enthalpy change of formation of sodium iodide	-288

- (a) Complete the Born-Haber cycle diagram for sodium iodide by adding the first ionisation energy of sodium and the first electron affinity of iodine. Include any relevant entities and arrow directions.

(3)



(b) Calculate the lattice energy for sodium iodide.

Give a sign and units in your answer.

(1)

(c) Explain why the enthalpy changes of atomisation of sodium and of iodine are endothermic. For each substance, state the type of bonding present in the solid.

(3)

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(d) The numerical value for the lattice energy of sodium iodide obtained from the Born-Haber cycle is more negative than the theoretical value.

(i) Explain why the Born-Haber value is more negative than the theoretical value.

(2)

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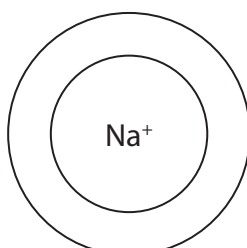
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(ii) Draw an electron density map for the iodide ion in sodium iodide showing any effect the sodium ion has on the iodide ion.

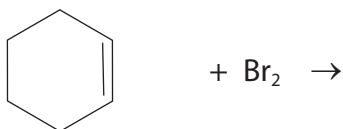
(1)



I⁻

16 The reaction of liquid bromine is a standard test for alkenes.

- (a) (i) Complete the equation for the reaction of cyclohexene with liquid bromine, using a skeletal formula.



(1)

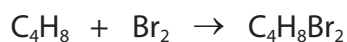
- (ii) What colour change would you see when this reaction occurs?

(1)

From to

- (b) Gaseous but-1-ene is another alkene that readily reacts with liquid bromine.

Using molecular formulae, the equation for the reaction is



- (i) Using the bond enthalpy values in the table, calculate the enthalpy change for this reaction.

(2)

Bond	Bond enthalpy / kJ mol ⁻¹
C—H	413
C—C	347
C=C	612
C—Br	290
Br—Br	193

- (ii) Give **one** reason why the value calculated for the reaction in part (b)(i) using bond enthalpies is different from the true value.
Do **not** consider experimental error, mean bond enthalpy values or non-standard conditions.

(1)

- (iii) Using appropriate curly arrows, write the mechanism of the reaction between but-1-ene and bromine.

(3)

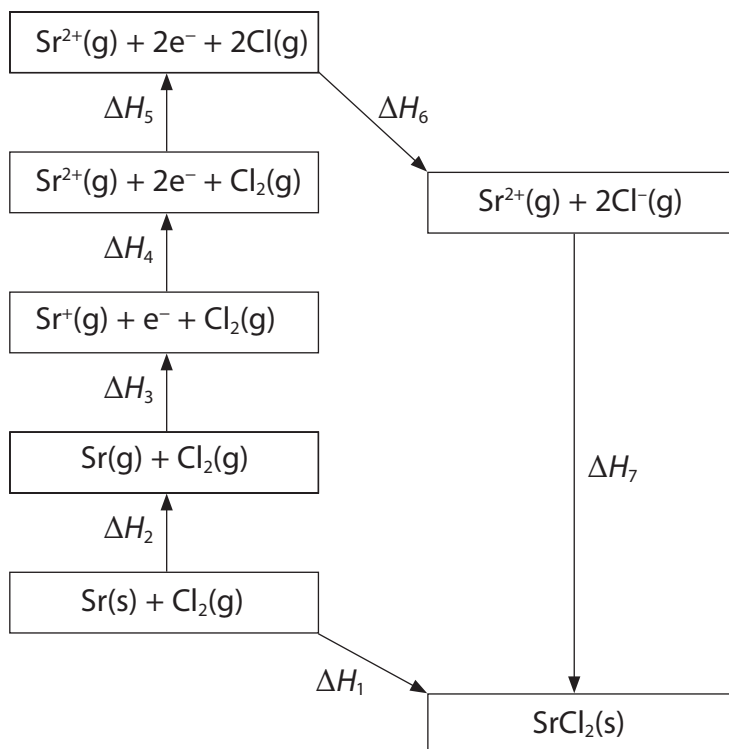
- (iv) Identify, by name or by displayed formula, the product formed when bromine **water** is added to but-1-ene.

(1)

(Total for Question 16 = 9 marks)

17 Born-Haber cycles can be used to determine experimental values of lattice energies.

(a) The diagram below shows a Born-Haber cycle for the formation of strontium chloride from strontium and chlorine.



Using symbols from ΔH_1 to ΔH_7 as appropriate, identify the

(i) enthalpy change of atomization of strontium (1)

(ii) bond enthalpy of chlorine (1)

(iii) first electron affinity of chlorine (1)

(iv) enthalpy change of formation of strontium chloride (1)

(b) The table below shows the energy changes that are needed to determine the lattice energy of strontium chloride, SrCl₂.

Energy change	$\Delta H / \text{kJ mol}^{-1}$
enthalpy change of atomization of strontium	+164
first ionization energy of strontium	+550
second ionization energy of strontium	+1064
enthalpy change of atomization of chlorine, $\frac{1}{2}\text{Cl}_2$	+122
first electron affinity of chlorine	-349
enthalpy change of formation of strontium chloride	-829

(i) Define the term **lattice energy**.

(2)

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(ii) Calculate the lattice energy of strontium chloride, in kJ mol^{-1} .

(2)

lattice energy = kJ mol^{-1}

*(c) The lattice energies of sodium fluoride and magnesium fluoride are shown in the table below.

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	-918
Magnesium fluoride, MgF_2	-2957

Explain, in terms of the sizes and charges of the ions involved, why the lattice energy of MgF_2 is more negative than that of NaF.

(3)

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(Total for Question 17 = 11 marks)

18 This question is about alkenes.

(a) Give the general formula for the homologous series of alkenes. (1)

(b) Give the **structural** formula of the organic product formed when **ethene**, $\text{CH}_2=\text{CH}_2$, reacts with

(i) hydrogen (1)

(ii) chlorine (1)

(iii) acidified aqueous potassium manganate(VII) (1)

(iv) bromine **water** (1)

(c) When **propene**, $\text{CH}_3\text{CH}=\text{CH}_2$, reacts with hydrogen chloride, there are **two** possible products, a major product and a minor product.

(i) Draw the **displayed** formulae of these products.

(2)

Major product	Minor product

(ii) Give the mechanism for the reaction of **propene** with hydrogen chloride which forms the major product.

(3)

(d) Propene can be polymerized.

- (i) Write a balanced equation for the polymerization of propene to form poly(propene), drawing the **displayed** formula of the repeat unit of poly(propene).

(3)

- (ii) State a problem associated with the disposal of waste poly(propene).

(1)

- (e) Standard enthalpy changes of combustion can be used to calculate the standard enthalpy change of formation of propene.



Values for some standard enthalpy changes of combustion, ΔH_c^\ominus , are shown in the table below.

Substance	$\Delta H_c^\ominus / \text{kJ mol}^{-1}$
C(s)	–394
H ₂ (g)	–286
C ₃ H ₆ (g)	–2058

- (i) Complete the Hess cycle below to enable you to calculate ΔH_f^\ominus from combustion data.

(1)



- (ii) Calculate ΔH_f^\ominus , in kJ mol⁻¹.

(2)

standard enthalpy change of formation of propene = kJ mol⁻¹

(Total for Question 18 = 17 marks)