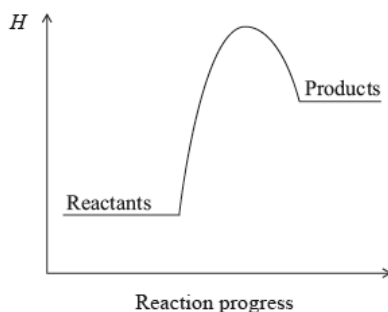


# Practice Test for Topic 5 Thermochemistry [22 marks]

1. Which statement is correct for the reaction with this enthalpy level diagram?

[1 mark]



- A. Heat energy is released during the reaction and the reactants are more stable than the products.  
B. Heat energy is absorbed during the reaction and the reactants are more stable than the products.  
C. Heat energy is released during the reaction and the products are more stable than the reactants.  
D. Heat energy is absorbed during the reaction and the products are more stable than the reactants.

## Markscheme

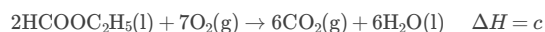
B

## Examiners report

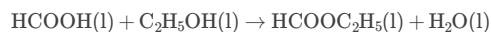
[N/A]

- 2a. The enthalpy changes of three reactions are given below.

[1 mark]



What is the enthalpy change for the following reaction?



- A.  $a + b + c$   
B.  $a + 2b - c$   
C.  $\frac{1}{2}a + b + \frac{1}{2}c$   
D.  $\frac{1}{2}a + b - \frac{1}{2}c$

## Markscheme

D

## Examiners report

[N/A]

2b. The specific heat capacities of two substances are given in the table below.

[1 mark]

Substance	Specific heat capacity / J g <sup>-1</sup> K <sup>-1</sup>
Ethanol	2.43
Water	4.18

Which statement is correct?

- A. More heat is needed to increase the temperature of 50 g of water by 50 °C than 50 g of ethanol by 50 °C.
- B. If the same heat is supplied to equal masses of ethanol and water, the temperature of the water increases more.
- C. If equal masses of water at 20 °C and ethanol at 50 °C are mixed, the final temperature is 35 °C .
- D. If equal masses of water and ethanol at 50 °C cool down to room temperature, ethanol liberates more heat.

## Markscheme

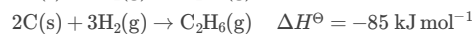
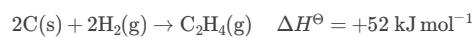
A

## Examiners report

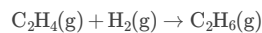
[N/A]

3. Enthalpy changes of reaction are provided for the following reactions.

[1 mark]



What is the enthalpy change, in kJ mol<sup>-1</sup>, for the reaction between ethene and hydrogen?



- A. -137
- B. -33
- C. +33
- D. +137

## Markscheme

A

## Examiners report

[N/A]

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

[1 mark]

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

## Markscheme

C

## Examiners report

[N/A]

5. Which equation best represents the bond enthalpy of HCl?

[1 mark]

- A.  $\text{HCl}(\text{g}) \rightarrow \text{H}^+(\text{g}) + \text{Cl}^-(\text{g})$   
B.  $\text{HCl}(\text{g}) \rightarrow \text{H}(\text{g}) + \text{Cl}(\text{g})$   
C.  $\text{HCl}(\text{g}) \rightarrow \frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{Cl}_2(\text{g})$   
D.  $2\text{HCl}(\text{g}) \rightarrow \text{H}_2(\text{g}) + \text{Cl}_2(\text{g})$

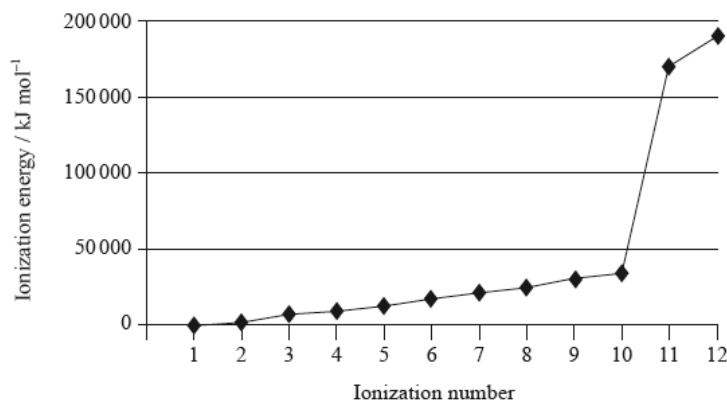
## Markscheme

B

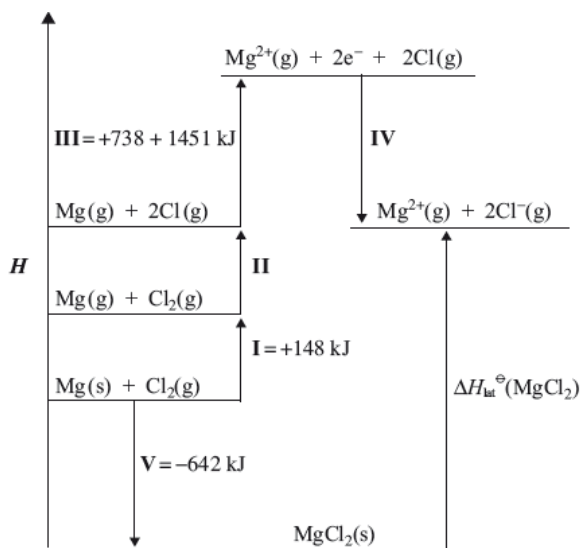
## Examiners report

[N/A]

Magnesium is the eighth most abundant element in the earth's crust. The successive ionization energies of the element are shown below.



The lattice enthalpy of magnesium chloride can be calculated from the Born-Haber cycle shown below.



6. (i) Identify the enthalpy changes labelled by I and V in the cycle. [10 marks]
- (ii) Use the ionization energies given in the cycle above and further data from the Data Booklet to calculate a value for the lattice enthalpy of magnesium chloride.
- (iii) The theoretically calculated value for the lattice enthalpy of magnesium chloride is +2326 kJ. Explain the difference between the theoretically calculated value and the experimental value.
- (iv) The experimental lattice enthalpy of magnesium oxide is given in Table 13 of the Data Booklet. Explain why magnesium oxide has a higher lattice enthalpy than magnesium chloride.

## Markscheme

(i) I:

atomization/sublimation (of Mg) /  $\Delta H_{\text{atomization}}^{\ominus}(\text{Mg})$  /  $\Delta H_{\text{sublimation}}^{\ominus}(\text{Mg})$ ;

V:

enthalpy change of formation of  $(\text{MgCl}_2)$  /  $\Delta H_{\text{formation}}^{\ominus}(\text{MgCl}_2)$ ;

(ii) Energy value for II:

+243;

Energy value for III:

$738 + 1451 = 2189$ ;

Energy value for IV:

$2(-349)$ ;

$\Delta H_{\text{lat}}^{\ominus}(\text{MgCl}_2) = 642 + 148 + 243 + 2189 - 2(349) = (-)2524 \text{ (kJ)}$ ;

(iii) theoretical value assumes ionic model;

experimental value greater due to (additional) covalent character;

(iv) oxide greater charge;

oxide smaller radius;

Accept opposite arguments.

## Examiners report

In (c) most candidates were familiar with the enthalpy changes of atomization and formation but some struggled with the Born Haber Cycle. Only the strongest candidates were able to relate differences in experimental and theoretical lattice energies to the covalent character of the solid with a significant number mistakenly giving "heat loss" as the reason for the difference.

7. Which step(s) is/are endothermic in the Born-Haber cycle for the formation of LiCl? [1 mark]

- A.  $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$  **and**  $\text{Li}(\text{s}) \rightarrow \text{Li}(\text{g})$   
B.  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$  **and**  $\text{Li}(\text{g}) \rightarrow \text{Li}^+(\text{g}) + \text{e}^-$   
C.  $\text{Li}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{LiCl}(\text{s})$   
D.  $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$  **and**  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$

## Markscheme

A

## Examiners report

In this question which referred to the Born-Haber cycle for the formation of LiCl, two respondents stated that the question was confusing especially for ESL candidates. In fact, the 68% of candidates got the correct answer, namely A and it was not felt that the wording of the question would have posed any problem even for ESL candidates.

8. Which ionic compound has the greatest lattice enthalpy? [1 mark]

- A. MgO  
B. CaO  
C. NaF  
D. KF

## Markscheme

A

## Examiners report

[N/A]

9. Which equation represents the electron affinity of chlorine?

[1 mark]

- A.  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- B.  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}(\text{g})$
- C.  $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{g})$
- D.  $\text{Cl}(\text{g}) \rightarrow \text{Cl}^+(\text{g}) + \text{e}^-$

## Markscheme

A

## Examiners report

[N/A]

10. Which combination of  $\Delta H$  and  $\Delta S$  signs will always result in a spontaneous reaction at all temperatures?

[1 mark]

	$\Delta H$	$\Delta S$
A.	+	+
B.	+	-
C.	-	-
D.	-	+

## Markscheme

D

## Examiners report

[N/A]

11b. Which reaction has the largest increase in entropy?

[1 mark]

- A.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
- B.  $\text{Al}(\text{OH})_3(\text{s}) + \text{NaOH}(\text{aq}) \rightarrow \text{Al}(\text{OH})_4^-(\text{aq}) + \text{Na}^+(\text{aq})$
- C.  $\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- D.  $\text{BaCl}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{NaCl}(\text{aq})$

## Markscheme

C

## Examiners report

[N/A]

11a. Which reaction has the largest increase in entropy?

[1 mark]

- A.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$
- B.  $\text{Al}(\text{OH})_3(\text{s}) + \text{NaOH}(\text{aq}) \rightarrow \text{Al}(\text{OH})_4^-(\text{aq}) + \text{Na}^+(\text{aq})$
- C.  $\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- D.  $\text{BaCl}_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{NaCl}(\text{aq})$

## Markscheme

C

## Examiners report

[N/A]