07 Chemical Energetics I

Set B Exam practice

Name | Time 1 hour | Total 33 marks | Score ____ / 33

A Data Booklet may be used.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
2 Standard Enthalpy Changes	2, 5(a), 9, 10(a)	6	4	
3 Calorimetry	10(b), 10(d)	3	2	
4 Hess' Law	5(b), 6(b), 7, 10(c)	11	7	
5 Lattice Energy and the Born–Haber Cycle	1, 3, 4, 6(a), 8, 11	13	8	

A Multiple choice

4 MARKS

1 COMMON Use of the Data Booklet is relevant to this question. In which row are the lattice energy values (kJ mol^{-1}) of the compounds correctly assigned?

	RbBr	CsBr	SrS	BaS
A	−2643	−2779	−619	−647
B	−2779	−2643	−647	−619
C	−647	−619	−2779	−2643
D	−619	−647	−2643	−2779

Answer ☐ [1]

/1

Source: IJC 2017 Promo, via EJC 2022 Chemical Energetics Topical Revision, Q4

2 Which has a positive enthalpy change of reaction?

A reaction between NaOH(aq) and HCl(aq)

B formation of carbon dioxide gas from carbon and oxygen gas

C formation of gaseous O^{2-} ion from gaseous O^{-} ion

D formation of Al_2O_3 solid from gaseous Al^{3+} and O^{2-}

Answer ☐ [1]

/1

Source: NJC 2018 Promo, via EJC 2022 Chemical Energetics Topical Revision, Q5

3 The following table shows the lattice energies for two silver halides.

compound	theoretical lattice energy / kJ mol^{-1}	experimental lattice energy / kJ mol^{-1}
AgBr	−759	−877
AgI	−736	−867

Which statement best explains the difference in the deviation of the experimental lattice energy from the theoretical lattice energy?

A The difference in electronegativity between Ag and the halogen is greater in AgBr than in AgI.

B The interionic distance in AgBr is smaller than that in AgI.

C The relative formula mass of AgBr is smaller than that of AgI.

D The I^- ion is more polarisable than the Br^- ion.

Answer [ ] [1]

/1

Source: 2025 RI J2 Prelim P1 Q11

4 When heated with oxygen, barium forms barium peroxide, BaO_2. The relevant enthalpy changes are shown in the table.

	enthalpy change / kJ mol^{-1}
$Ba(g) \rightarrow Ba^{2+}(g) + 2e^-$	p
$Ba^{2+}(g) + O_2^{2-}(g) \rightarrow BaO_2(s)$	q
$Ba(s) \rightarrow Ba(g)$	r
$Ba(s) + O_2(g) \rightarrow BaO_2(s)$	s

What is the enthalpy change of the following reaction? $O_2(g) + 2e^- \rightarrow O_2^{2-}(g)$

A s − q + p − r **B** s − q − p − r **C** r − s + p + q **D** r − s + p − q

Answer [ ] [1]

/1

Source: 2025 RI J2 Prelim P1 Q12

B Structured questions

29 MARKS

5 COMMON Diborane, B_2H_6, is used in rocket fuels. It can be formed from its elements according to the equation $2B(s) + 3H_2(g) \rightarrow B_2H_6(g)$. The following data are given.

$2B(s) + \frac{3}{2}O_2(g) \rightarrow B_2O_3(s)$	$\Delta H_1^{\ominus} = -1273$ kJ mol^{-1}
$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(l)$	$\Delta H_2^{\ominus} = -2035$ kJ mol^{-1}
$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$	$\Delta H_3^{\ominus} = -242$ kJ mol^{-1}

(a) Name the enthalpy change represented by $\Delta H_1^{\ominus}$.

..... [1]

(b) Construct a suitable energy cycle and calculate the enthalpy change of formation of diborane, $B_2H_6(g)$.

[3]

/4

Source: 2025 CJC J2 Prelim P2 Q1(a)

6 COMMON Lithium hydride can be prepared by passing hydrogen gas over heated lithium. The following data will be useful in this question.

enthalpy change of formation of LiH(s)	-90.5 kJ mol^{-1}
enthalpy change of atomisation of Li(s)	$+159.5$ kJ mol^{-1}
electron affinity of hydrogen atoms	-73.0 kJ mol^{-1}
enthalpy change of formation of $AlCl_3$(s)	-704 kJ mol^{-1}
enthalpy change of formation of LiCl(s)	-408.5 kJ mol^{-1}

(a) Calculate the lattice energy of LiH(s) using relevant data from the above list, together with relevant data from the Data Booklet.

[2]

(b) When heated with anhydrous aluminium chloride, lithium hydride forms lithium aluminium hydride, $LiAlH_4$. Lithium chloride is also produced. The enthalpy change for this reaction is −276 kJ per mole of $LiAlH_4$ formed. Write an equation, with state symbols, for this reaction and use it together with the relevant data from the above list to calculate a value for the enthalpy change of formation of $LiAlH_4$.

[3]

/5

Source: 2023 CJC J2 Prelim P3 Q1(a)

7 Bromine and fluorine react together to give bromine trifluoride. $Br_2(l) + 3F_2(g) \rightarrow 2BrF_3(l)$

Construct a fully labelled energy cycle relating the reactants and products of this reaction to their gas phase atoms. Use your cycle to calculate the average bond energy of the Br–F bond in BrF_3. Your cycle should include relevant data from the Data Booklet together with the following data.

standard enthalpy change of formation of $BrF_3(l)$	−301 kJ mol^{-1}
enthalpy change of vaporisation of $Br_2(l) \rightarrow Br_2(g)$	+31 kJ mol^{-1}
enthalpy change of vaporisation of $BrF_3(l) \rightarrow BrF_3(g)$	+44 kJ mol^{-1}

[3]

/3

Source: A Level 2016 P3 Q2(b), via EJC 2022 JC1 Chemical Energetics Tutorial, B5(a)

8 Using the data in the table and the Data Booklet, calculate the lattice energy of Ca_2SiO_4 with the aid of an energy cycle. You may assume that the lattice of Ca_2SiO_4 comprises Ca^{2+} and SiO_4^{4-} ions.

	value / kJ mol^{-1}
standard enthalpy change of atomisation of Ca(s)	+121
standard enthalpy change of formation of Ca_2SiO_4(s)	−2306
enthalpy change of the reaction $Si(s) + 2O_2(g) + 4e^- \rightarrow SiO_4^{4-}(g)$	+13872

[3]

/3

Source: 2023 RI J2 Prelim P3 Q1(c)

9 **(a)** Define the term enthalpy change of neutralisation.

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[1]

(b) An experiment with hydrogen cyanide, HCN(aq), and aqueous ammonia gave a value of −5.4 kJ mol^{-1} for the enthalpy change of neutralisation. The corresponding value for sodium hydroxide with hydrochloric acid was −57.0 kJ mol^{-1}. Suggest a possible explanation for the difference in these two values.

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[2]

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Source: RJC H2 Chemistry Tutorial 5a (Chemical Energetics I), Q4(a) and (d)

10 Environmental chemists burnt a sample of solid sulfur collected near a volcano and measured the temperature change of a fixed mass of water in a calorimeter. Their data are shown below.

mass of solid sulfur powder burnt / g	0.76
mass of water / g	150

initial temperature of water / °C	29.8
final temperature of water / °C	39.7

(a) Construct an equation to represent the standard enthalpy change of combustion of solid sulfur, S.

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[1]

(b) COMMON Calculate the enthalpy change of combustion of solid sulfur, S, based on this experiment.

[2]

In the atmosphere, hydrogen sulfide is oxidised to sulfur dioxide: $H_2S(g) + 3/2O_2(g) \rightarrow SO_2(g) + H_2O(l)$, $\Delta H_r = -562$ kJ mol^{-1}. The enthalpy changes of formation of $H_2S(g)$ and $H_2O(l)$ are −20.6 and −285.8 kJ mol^{-1}.

(c) Use these data to calculate the enthalpy change of combustion of solid sulfur, S.

[2]

(d) Comment on the difference between the values for the enthalpy change of combustion of solid sulfur found in (b) and (c).

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[1]

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Source: 2025 EJC J2 Prelim P2 Q1(a)(i) to (iv)

11 CHALLENGE The following information is given.

energy change	/ kJ mol^{-1}
atomisation energy of Cu	+339
first electron affinity of O	−141
second electron affinity of O	+791
enthalpy change of formation of copper(I) oxide	−166

(a) Using this information and the Data Booklet, construct a Born–Haber diagram and calculate the lattice energy of copper(I) oxide, Cu_2O.

[3]

(b) The lattice energy of copper(II) oxide is –4143 kJ mol^{-1}. Explain why this value is different from the one calculated in (a).

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Source: RJC H2 Chemistry Tutorial 5a (Chemical Energetics I), Q8(a) and (b)