

OCR A-Level Chemistry A

Lattice enthalpy, entropy and free energy

Questions only

The newest questions, about an hour. All 16 are in the exam generator.

Questions

9

Total marks

44

Time allowed

59 min

Name

Class or teacher

Date

Instructions

- Answer all questions in the spaces provided.
- Use black ink. Show your working for every calculation.
- You may use a scientific calculator and the OCR Data Sheet.
- Print the separate mark scheme when you are ready to mark your answers.

For marking

Q	Source	Marks	Score
1	2022 P1 Q10	1	
2	2022 P1 Q9	1	
3	2023 P1 Q15	1	
4	2023 P1 Q16	10	
5	2023 P1 Q18	11	
6	2023 P1 Q9	1	
7	2024 P1 Q16	17	
8	2025 P1 Q3	1	
9	2021 P1 Q11	1	

Total _____ / 44 Percentage _____ %

Questions from OCR past papers, 2021–2025, reproduced for revision. Practise these topics online, with instant marking:

whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=lattice-enthalpy-entropy-and-free-energy&len=0

Questions

Lattice enthalpy, entropy and free energy · 9 questions · 44 marks · time allowed 59 min

Q1 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q10 · [1 mark]

For the condensation of ammonia gas, what are the signs of ΔH and ΔS ?

Tick (✓) one box.

- ☐ **A** ΔH -ve · ΔS -ve
- ☐ **B** ΔH -ve · ΔS +ve
- ☐ **C** ΔH +ve · ΔS +ve
- ☐ **D** ΔH +ve · ΔS -ve
-

Q2 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

Which equation represents the change that accompanies the standard enthalpy change of atomisation of bromine?

Tick (✓) one box.

- ☐ **A** $\frac{1}{2} \text{Br}_2(\text{l}) \rightarrow \text{Br}(\text{g})$
- ☐ **B** $\text{Br}_2(\text{l}) \rightarrow 2\text{Br}(\text{g})$
- ☐ **C** $\frac{1}{2} \text{Br}_2(\text{g}) \rightarrow \text{Br}(\text{g})$
- ☐ **D** $\text{Br}_2(\text{g}) \rightarrow 2\text{Br}(\text{g})$

Q3 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q15 · [1 mark]

Chlorine trifluoride can be decomposed into its elements forming the equilibrium mixture below.

$2\text{ClF}_3(\text{g})$	$\rightleftharpoons$	$\text{Cl}_2(\text{g})$	+	$3\text{F}_2(\text{g})$	$\Delta H = +318 \text{ kJ mol}^{-1}$
colourless gas		green gas		yellow gas	

Which statement(s) is/are correct?

- 1 The decomposition is a redox reaction.
- 2 When the equilibrium mixture is cooled, the colour fades.
- 3 The decomposition has a negative entropy change.

Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q4 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q16 · [10 marks]

This question also needs Periodicity.

This question is about energy changes.

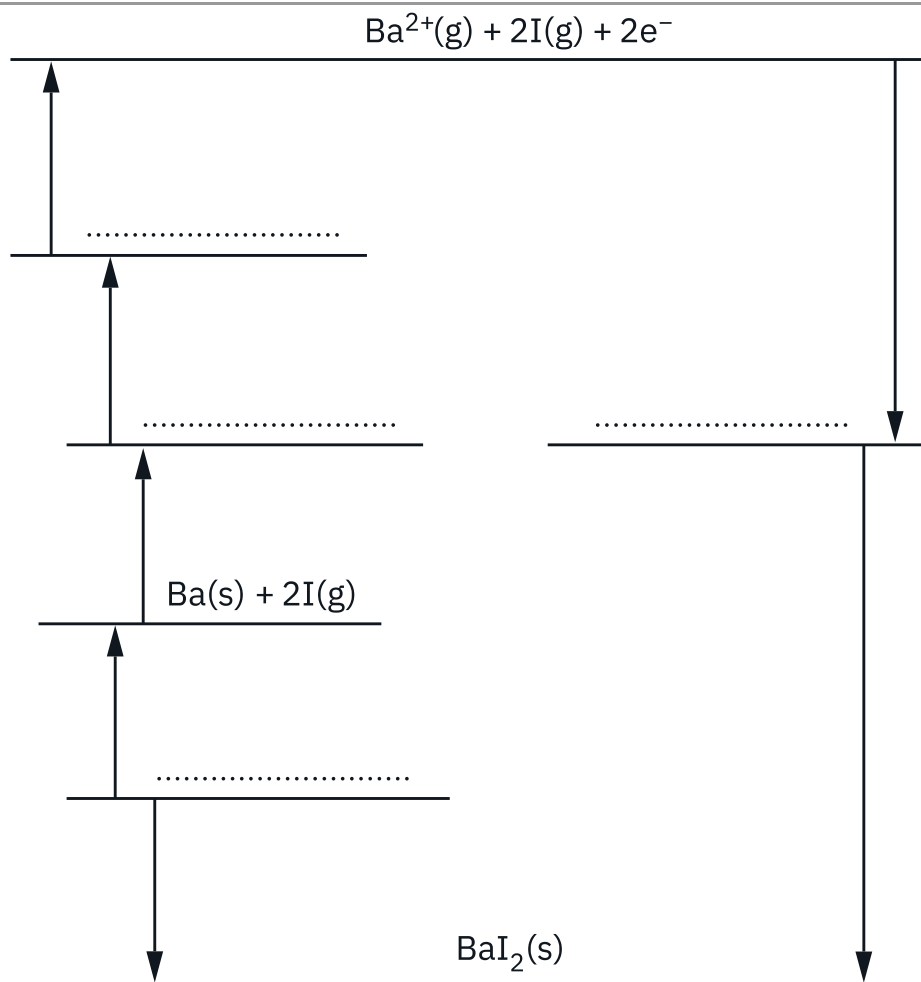
Lattice enthalpies can be determined indirectly using Born-Haber cycles.

The table below shows the energy changes that are needed to determine the lattice enthalpy of barium iodide, BaI_2 .

Energy term	Energy change / kJ mol^{-1}
formation of barium iodide	-602
1st electron affinity of iodine	-296
1st ionisation energy of barium	+503
2nd ionisation energy of barium	+965
atomisation of iodine	+107
atomisation of barium	+180

16(a)(i) The diagram below shows an incomplete Born-Haber cycle that can be used to calculate the lattice enthalpy of barium iodide.

On the dotted lines, add the species present, including state symbols.



[4 marks]

16(a)(ii) Calculate the lattice enthalpy of barium iodide.

lattice enthalpy = kJ mol^{-1}

[2 marks]

16(b) The first and second ionisation energies of magnesium, Mg, and strontium, Sr, in Group 2 are given in the table below.

Element	First ionisation energy / kJ mol^{-1}	Second ionisation energy / kJ mol^{-1}
Mg	+738	+1451
Sr	+550	+1064

- Explain why the first ionisation energy of Mg is greater than the **first** ionisation energy of Sr.
- Explain why the second ionisation energy of Sr is greater than the **first** ionisation energy of Sr.

[4 marks]

Q5 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q18 · [11 marks]

This question also needs Enthalpy changes.

This question is about enthalpy changes of reactions involving hydrocarbons.

18(a) A student determines the enthalpy change of combustion, $\Delta_c H$, of heptane, C_7H_{16} , using the method outlined below.

- Add 150 g of water to a beaker and measure its temperature.
- Weigh a spirit burner containing heptane and use it to heat the water.
- Extinguish the flame and record the maximum temperature reached by the water.
- Reweigh the spirit burner.

The temperature of the water increased by 10.5 °C.

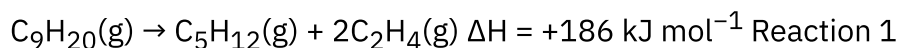
The spirit burner decreased in mass by 0.133 g.

Use the student's results to determine the enthalpy change of combustion of heptane, $\Delta_c H$ (C_7H_{16}), in kJ mol^{-1} .

$\Delta_c H (C_7H_{16}) = \text{kJ mol}^{-1}$

[3 marks]

18(b) Nonane, C_9H_{20} , can be broken down by heat to form pentane, C_5H_{12} , and ethene, C_2H_4 .



The enthalpy changes of combustion of $C_9H_{20}(g)$ and $C_2H_4(g)$ are shown in the table below.

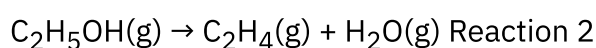
Hydrocarbon	$\Delta_c H / \text{kJ mol}^{-1}$
$C_9H_{20}(g)$	-6171
$C_2H_4(g)$	-1411

Use ΔH in Reaction 1 and the enthalpy changes of combustion in the table to determine the enthalpy change of combustion of $C_5H_{12}(g)$.

$$\Delta_c H (C_5H_{12}(g)) = \text{kJ mol}^{-1}$$

[2 marks]

Ethene can be produced from ethanol, as shown in Reaction 2 below.

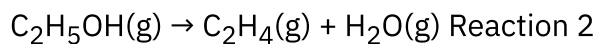


18(c)(i) Predict the sign of the entropy change, ΔS , for Reaction 2.

Explain your reasoning.

[1 mark]

18(c)(ii) Reaction 2 is repeated:



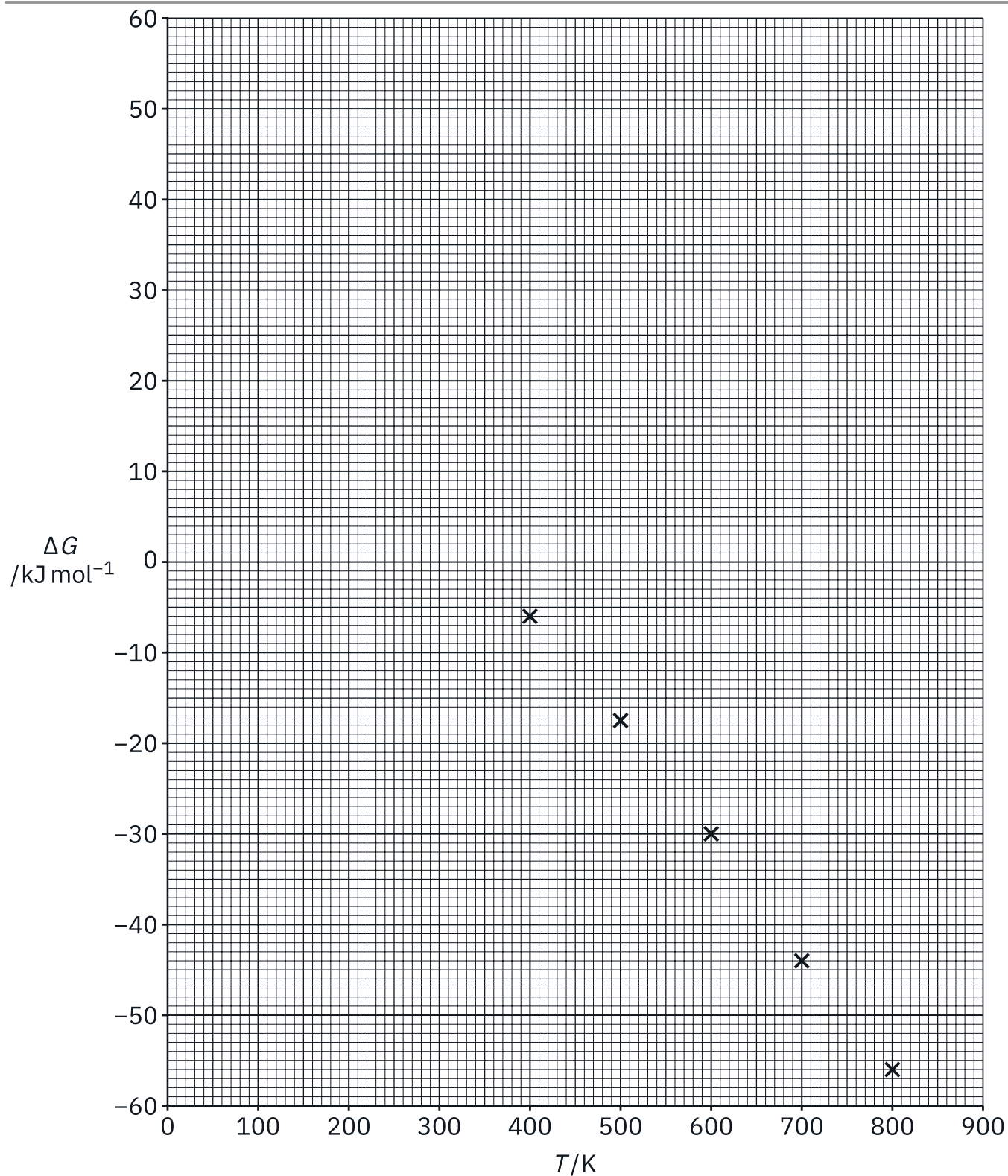
The Gibbs equation is shown below.

$$\Delta G = \Delta H - T\Delta S$$

The enthalpy change, ΔH , and the entropy change, ΔS , can be assumed to be constant at different temperatures.

Fig. 18.1 shows values of the free energy change, ΔG , in kJ mol^{-1} , at different temperatures, T , in K, for Reaction 2.

Fig. 18.1



Use the graph in Fig. 18.1 to answer the following:

- Draw the best-fit line on the graph in Fig. 18.1.
- Determine ΔS , in $\text{J K}^{-1} \text{mol}^{-1}$, for Reaction 2.
- Determine the minimum temperature, T , at which the reaction is feasible.
- Determine ΔH for Reaction 2.

$$\Delta S = \text{J K}^{-1} \text{ mol}^{-1}$$

minimum $T = \text{K}$

$$\Delta H = \text{kJ mol}^{-1}$$

[5 marks]

Draw your answer on the figure above.

Q6 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

The table below shows standard entropies, $S^\ominus$.

Substance	$\text{SO}_2(\text{g})$	$\text{O}_2(\text{g})$	$\text{SO}_3(\text{l})$
$S^\ominus / \text{J K}^{-1} \text{ mol}^{-1}$	248	204	96

What is the standard entropy change, $\Delta S^\ominus$, in J K mol^{-1} , for the formation of 1 mol of $\text{SO}_3(\text{l})$ from $\text{SO}_2(\text{g})$ and $\text{O}_2(\text{g})$?

Tick (✓) one box.

☐ **A** -508

☐ **B** -254

☐ **C** +254

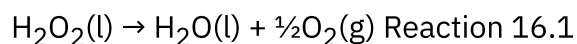
☐ **D** +508

Q7 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q16 · [17 marks]

This question also needs Enthalpy changes and Reaction rates and equilibrium.

This question is about energy changes.

Hydrogen peroxide decomposes as shown in Reaction 16.1.



The table shows enthalpy changes of formation and entropies.

	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
$\text{H}_2\text{O}_2(\text{l})$	-188	110
$\text{H}_2\text{O}(\text{l})$	-286	70.0
$\text{O}_2(\text{g})$	0	205

16(a)(i) Calculate the free-energy change, ΔG , in kJ mol^{-1} , of Reaction 16.1 at 25 °C.

Give your answer to **3** significant figures.

$\Delta G = \text{kJ mol}^{-1}$

[4 marks]

16(a)(ii) The decomposition of hydrogen peroxide shown in Reaction 16.1 is feasible.

Suggest why Reaction 16.1 does **not** take place at 25 °C despite being feasible.

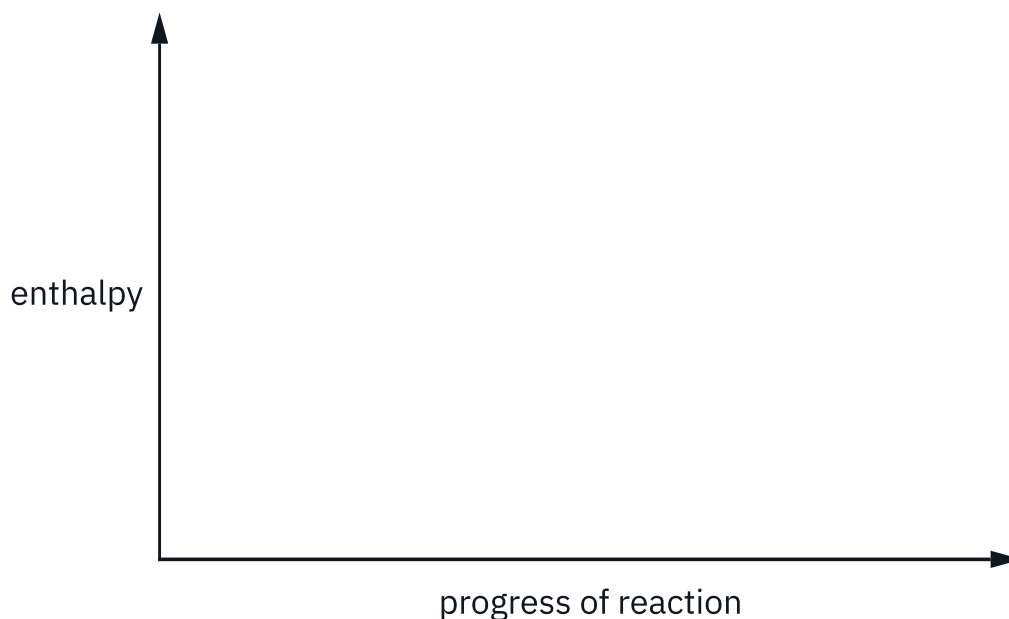
[1 mark]

The rate of decomposition of hydrogen peroxide shown in Reaction 16.1 can be increased by adding a small amount of powdered manganese(IV) oxide, MnO_2 .

The MnO_2 acts as a catalyst.

16(b)(i) Complete the enthalpy profile diagram for Reaction 16.1 using formulae for the reactants and products.

- Use E_a to label the activation energy **without** MnO_2 .
- Use E_c to label the activation energy **with** MnO_2 .
- Use ΔH to label the enthalpy change of reaction.



[3 marks]

Draw your answer on the figure above.

16(b)(ii) Explain why MnO_2 is described as a **heterogeneous** catalyst for this reaction.

[1 mark]

16(b)(iii) Mn_3O_4 is a compound in which Mn has two different oxidation states. The two oxidation states are different from the Mn in MnO_2 .

Suggest the two oxidation states of manganese in Mn_3O_4 .

[1 mark]

Manganese(II) oxide, MnO , has a giant ionic lattice structure.

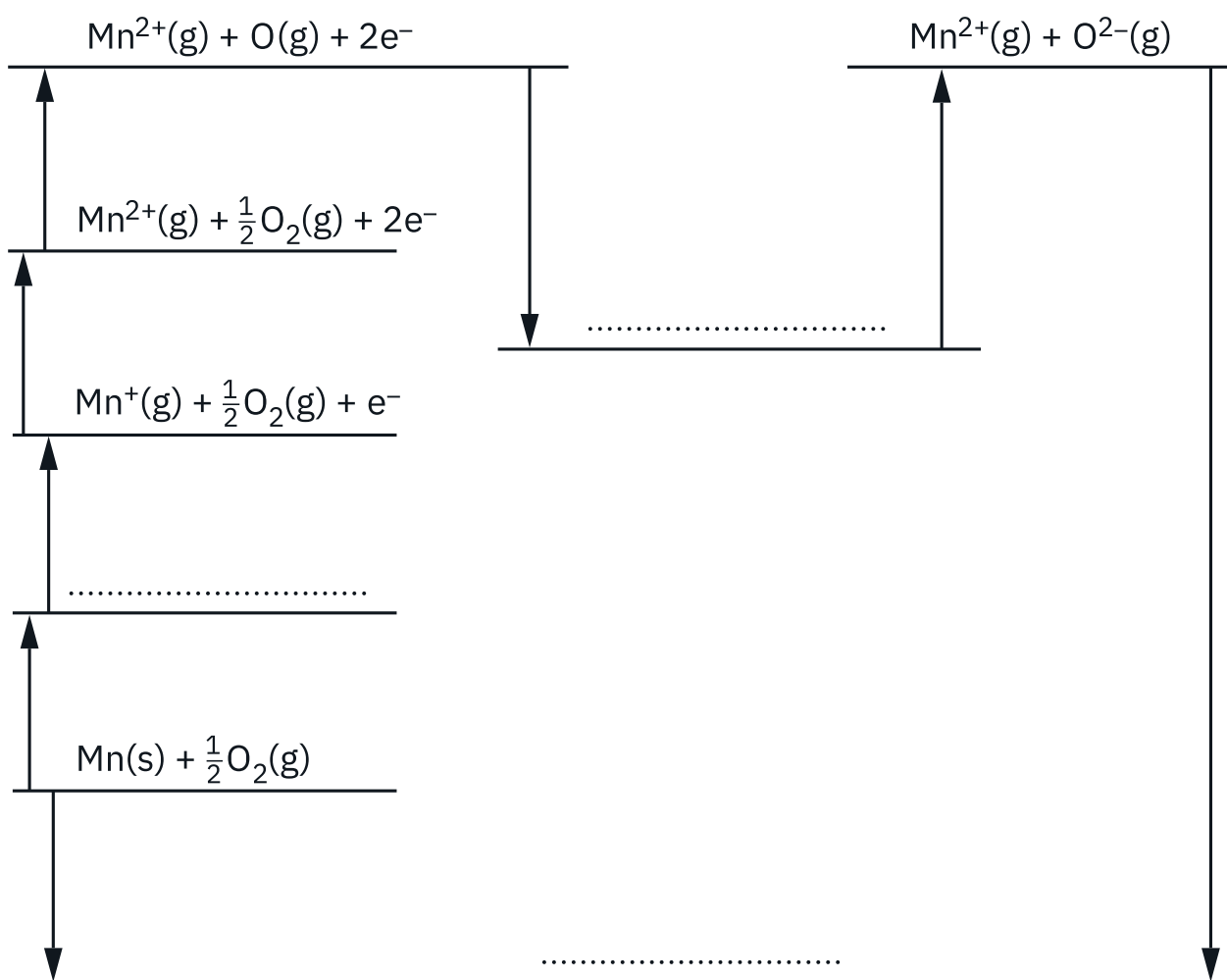
The table shows the enthalpy changes that are needed to determine the lattice enthalpy of MnO .

	enthalpy change / kJ mol^{-1}
atomisation of manganese	+281
atomisation of oxygen	+249
first ionisation energy of manganese	+717
second ionisation energy of manganese	+1509
first electron affinity of oxygen	-141
second electron affinity of oxygen	+798
formation of manganese(II) oxide	-385

16(c)(i) Define the term **lattice enthalpy**.

[2 marks]

16(c)(ii) The diagram shows an incomplete Born-Haber cycle that can be used to determine the lattice enthalpy of MnO.



Complete the diagram by adding the species present on the dotted lines, include state symbols.

[3 marks]

Draw your answer on the figure above.

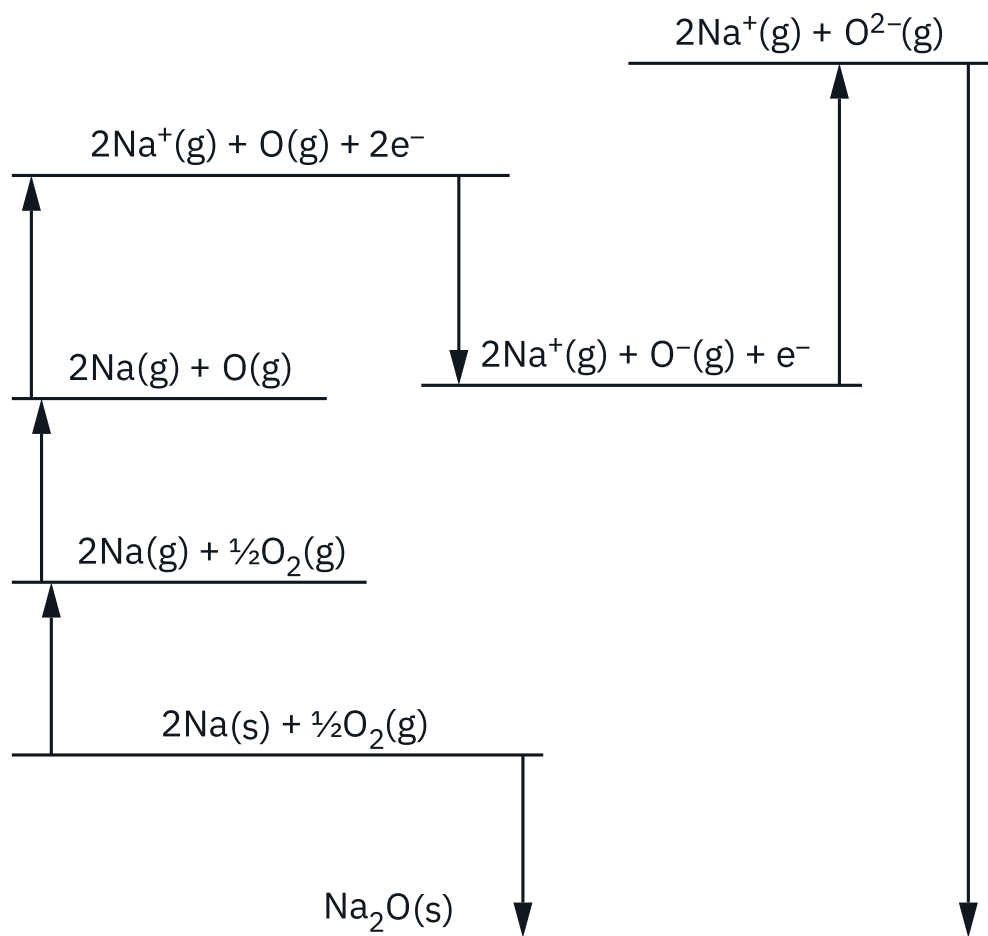
16(c)(iii) Calculate the lattice enthalpy of MnO.

lattice enthalpy = kJ mol^{-1}

[2 marks]

Q8 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q3 · [1 mark]

The diagram shows the Born-Haber cycle for sodium oxide, Na_2O .



Why is the value for the second electron affinity of oxygen positive?

Tick (✓) one box.

- ☐ **A** An electron is added to a high energy orbital.
- ☐ **B** An electron is added to a negative ion.
- ☐ **C** An electron is removed from a gaseous atom.
- ☐ **D** An electron is removed from a positive ion.

Q9 · November 2021 · Paper 1 (Periodic table, elements and physical chemistry) · Q11 · [1 mark]

The feasibility of a chemical reaction depends on the temperature and the signs of ΔH and ΔS .

Which row has signs for ΔH and ΔS for a reaction that is feasible at high temperatures but is not feasible at low temperatures?

Tick (✓) one box.

☐ **A** $\Delta H: + \cdot \Delta S: +$

☐ **B** $\Delta H: + \cdot \Delta S: -$

☐ **C** $\Delta H: - \cdot \Delta S: +$

☐ **D** $\Delta H: - \cdot \Delta S: -$

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