Bonding

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Bonding
Booklet	Question Paper

Time Allowed: **90 minutes**

Score: **/76**

Percentage: **/100**

Grade Boundaries:

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

1 Which row in the table shows the lattice energies, in kJ mol^{-1}, of calcium fluoride, potassium fluoride and potassium iodide?

	Calcium fluoride	Potassium fluoride	Potassium iodide
☒ **A**	–2630	–817	–651
☒ **B**	–2630	–651	–817
☒ **C**	–651	–817	–2630
☒ **D**	–817	–2630	–651

(Total for Question 1 = 1 mark)

2 The experimental value for the lattice energy of beryllium iodide is −2800 kJ mol^{-1} and the theoretical value is –2653 kJ mol^{-1}.

The best explanation for the difference is that the

☒ **A** beryllium ion is large and polarizes the iodide ion.

☒ **B** beryllium ion is small and polarizes the iodide ion.

☒ **C** iodide ion is large and polarizes the beryllium ion.

☒ **D** iodide ion is small and polarizes the beryllium ion.

(Total for Question 2 = 1 mark)

3 Carbon (diamond) and oxygen both form covalent bonds between their atoms in the element.

What is the **best** reason for the fact that diamond has a much higher melting temperature than oxygen?

☒ **A** Diamond is a solid but oxygen is a gas at room temperature.

☒ **B** Diamond has a giant atomic structure but oxygen has a simple molecular structure.

☒ **C** The covalent bonds between carbon atoms in diamond are stronger than those between oxygen atoms.

☒ **D** There is a single covalent bond between carbon atoms in diamond but a double covalent bond between oxygen atoms.

(Total for Question 3 = 1 mark)

4 The bonding in solid ammonium chloride is

☒ **A** ionic only.

☒ **B** ionic and covalent only.

☒ **C** ionic and dative covalent only.

☒ **D** ionic, covalent and dative covalent only.

(Total for Question 4 = 1 mark)

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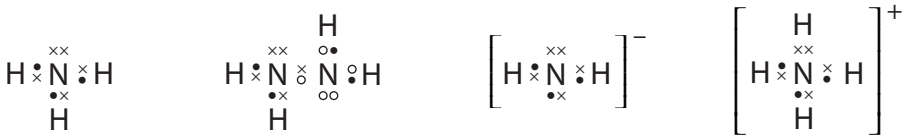
5 Nitrogen can form the following species with hydrogen:



NH_3 NH_2NH_2 NH_2^- NH_4^+

Which of these species has a dative covalent bond?

☒ **A** NH_3

☒ **B** NH_2NH_2

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 5 = 1 mark)

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6 Which of the following compounds has the greatest ionic character?

☒ **A** Caesium fluoride

☒ **B** Caesium iodide

☒ **C** Potassium fluoride

☒ **D** Potassium iodide

(Total for Question 6 = 1 mark)

7 Which species has a dative covalent bond?

☒ **A** H_3O^+

☒ **B** H_2O

☒ **C** OH^-

☒ **D** O_2

(Total for Question 7 = 1 mark)

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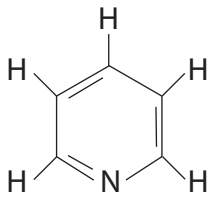
8 A molecule of **Z** has the following structure:



Molecule of **Z**

What are the total numbers of σ-bonds and π-bonds in a molecule of **Z**?

	Number of σ-bonds	Number of π-bonds
☒ **A**	3	11
☒ **B**	8	3
☒ **C**	11	3
☒ **D**	14	6

(Total for Question 8 = 1 mark)

9 Which of the following contains a dative covalent bond?

- ☒ **A** N_2
- ☒ **B** NH_3
- ☒ **C** NH_2^-
- ☒ **D** NH_4^+

(Total for Question 9 = 1 mark)

10 Potassium combines with iodine to form potassium iodide.

Which of the following describes the bonding in the three substances?

	Potassium	Iodine	Potassium iodide
☒ **A**	ionic	covalent	ionic
☒ **B**	metallic	ionic	covalent
☒ **C**	covalent	covalent	ionic
☒ **D**	metallic	covalent	ionic

(Total for Question 10 = 1 mark)

11 Metallic bonding is **best** described as the electrostatic attraction between

- ☒ **A** positive ions and delocalized electrons.
- ☒ **B** protons and electrons.
- ☒ **C** positive and negative ions.
- ☒ **D** nuclei and shared pairs of electrons.

(Total for Question 11 = 1 mark)

12 A liquid, which conducts electricity, continues to conduct when it is cooled and solidified. Which of the following could it be?

- ☒ **A** Mercury
- ☒ **B** Bromine
- ☒ **C** Molten sodium chloride
- ☒ **D** Tetrachloromethane

(Total for Question 12 = 1 mark)

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13 Which of the following molecules contains a double bond?

- ☒ **A** F_2
- ☒ **B** F_2O
- ☒ **C** C_2F_4
- ☒ **D** C_2F_6

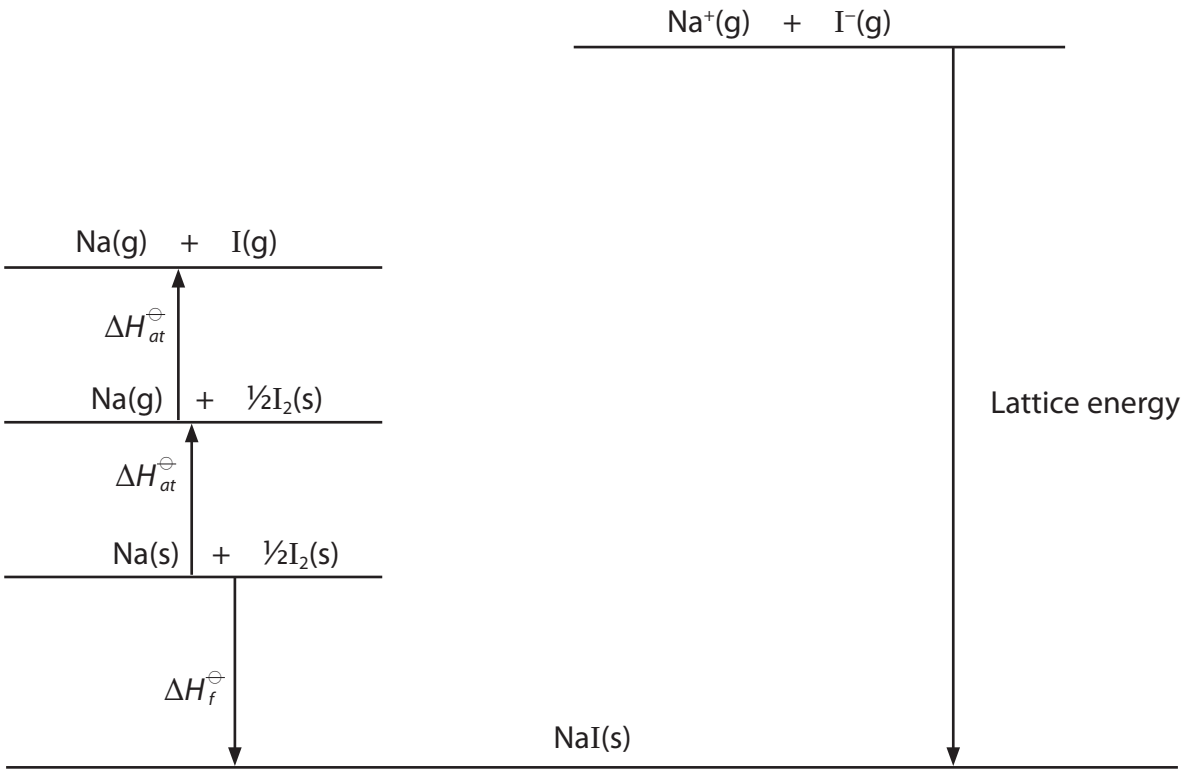
(Total for Question 13 = 1 mark)

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

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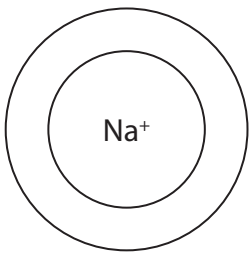
(ii) Draw an electron density map for the iodide ion in sodium iodide showing any effect the sodium ion has on the iodide ion.

(1)



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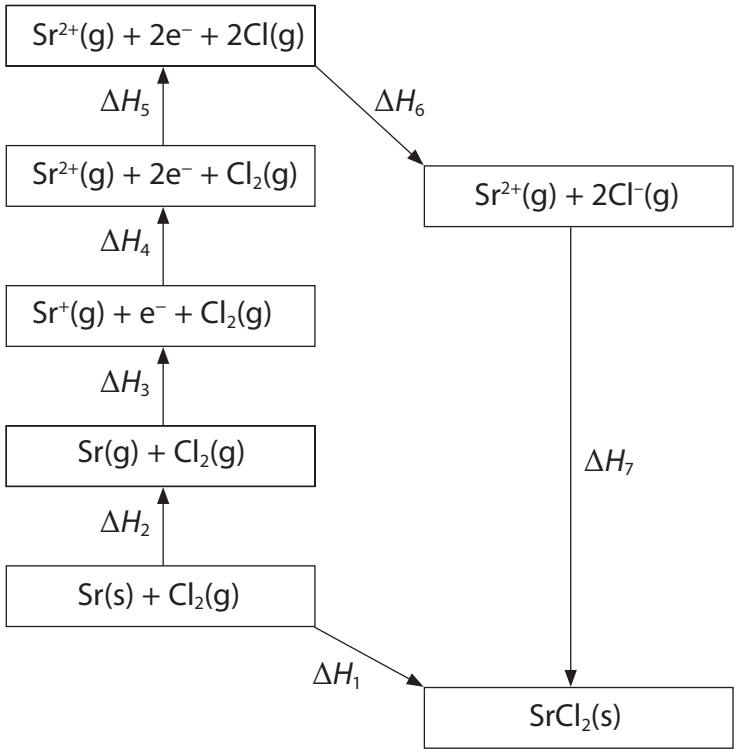
(Total for Question 14 = 10 marks)

15 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)

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(ii) bond enthalpy of chlorine

(1)

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(iii) first electron affinity of chlorine

(1)

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(iv) enthalpy change of formation of strontium chloride

(1)

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(b) The table below shows the energy changes that are needed to determine the lattice energy of strontium chloride, $SrCl_2$.

Energy change	ΔH / 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, $\frac{1}{2}Cl_2$	+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 15 = 11 marks)

16 A model of the atom describes a nucleus containing protons and neutrons surrounded by electrons in energy levels.

(a) Complete the table below.

(3)

Sub-atomic particle	Relative mass	Relative charge
proton		
neutron		
electron		

(b) State, in terms of the sub-atomic particles present, the meaning of the term **isotopes**.

(2)

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(c) The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb.

(i) Explain how gaseous atoms of rubidium are ionized in a mass spectrometer.

(2)

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(ii) In a sample of rubidium, the isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb.

Calculate the relative atomic mass of rubidium in this sample. Give your answer to **one** decimal place.

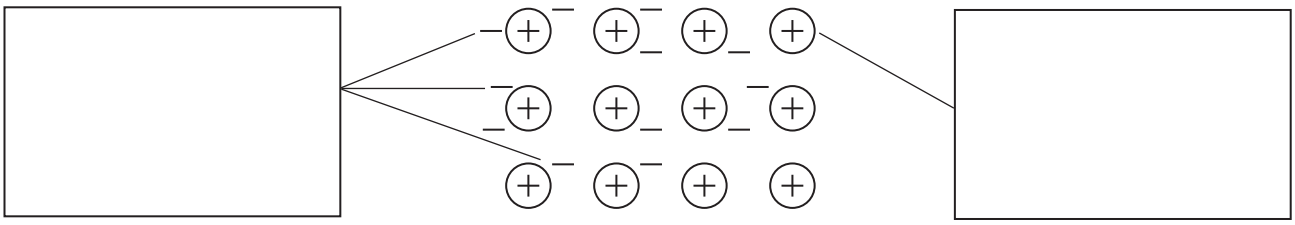
(3)

Relative atomic mass = ...

(d) The diagram below illustrates a model of the metallic bonding in rubidium.

Write appropriate labels in the two empty boxes in order to complete the diagram.

(2)



(Total for Question 16 = 12 marks)

17 Barium chloride can be made by reacting solid barium carbonate with dilute hydrochloric acid in the following reaction.

$$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) (i) Write the ionic equation for the reaction of solid barium carbonate with hydrogen ions from the hydrochloric acid. State symbols are not required.

(1)

(ii) State **two** observations you would make while the reaction is taking place. No change of colour occurs.

(2)

Observation 1 .....

Observation 2 .....

(b) In an experiment to prepare crystals of hydrated barium chloride, $BaCl_2.2H_2O$, a volume of 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid, HCl, was transferred to a beaker and solid barium carbonate, $BaCO_3$, was added until it was in excess.

(i) How many moles of acid were used in the reaction?

(1)

(ii) What mass of barium carbonate, in grams, reacts with this amount of acid?

The molar mass of barium carbonate is 197.3 g mol^{-1}.

(1)

(iii) Why was an **excess** of barium carbonate used in the experiment?

(1)

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(iv) How would you separate the barium chloride solution from the reaction mixture in part (iii)?

(1)

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(v) The barium chloride solution was left to crystallize. The crystals were separated and dried carefully. A sample of 5.35 g of hydrated crystals, $BaCl_2.2H_2O$, which has molar mass 244 g mol^{-1}, was obtained. Calculate the percentage yield of this reaction.

(2)

(vi) Give **one** reason why the yield of crystals is less than 100%, even when the reactants contain no impurities.

(1)

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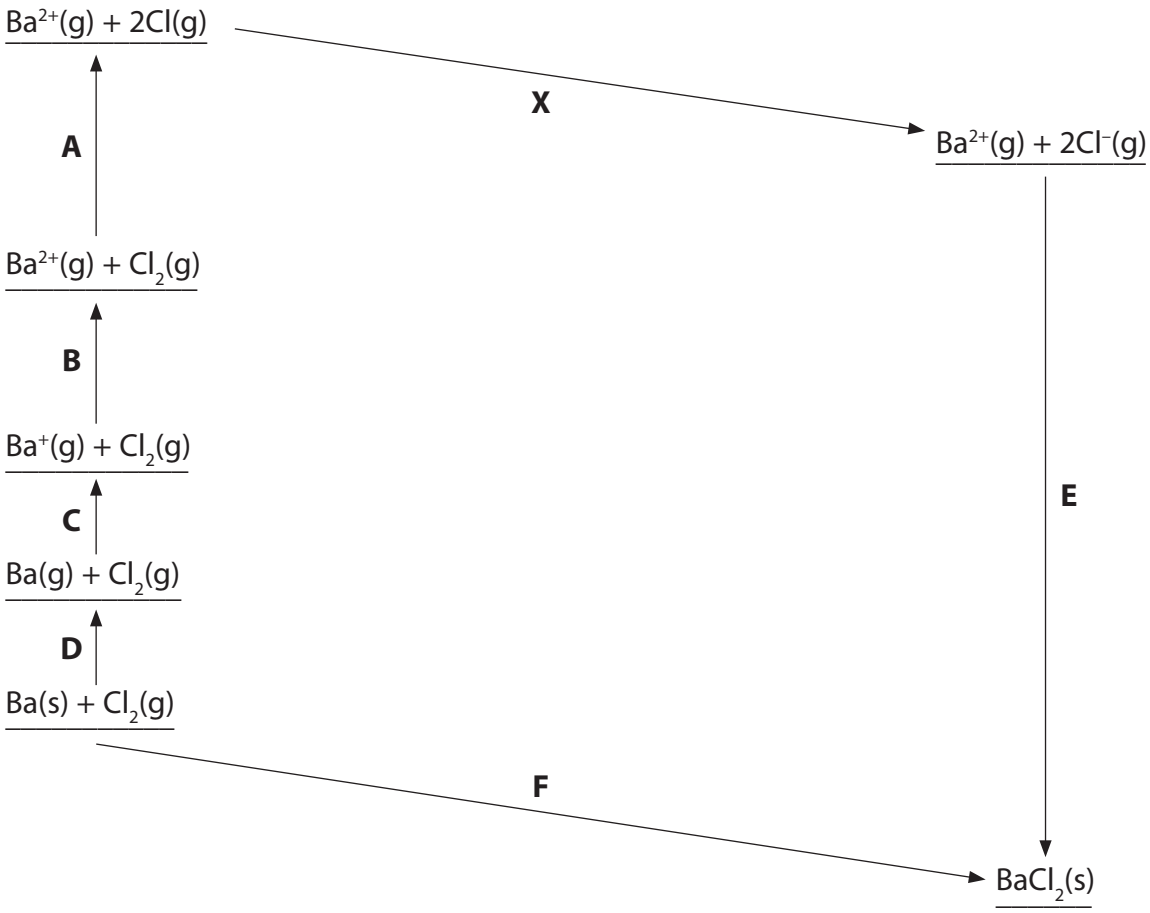
(c) The diagram below, which is not drawn to scale, shows how the lattice energy of barium chloride can be calculated using the Born-Haber cycle.



(i) Using the letters **A** to **F**, complete the table below by matching each letter to its corresponding energy change.

(3)

(ii) The energy change **X** is –697.6 kJ mol^{-1}.

In the table, add the name of the enthalpy change which is occurring in this stage of the cycle.

(1)

Energy change	Letter	ΔH / kJ mol^{-1}
Lattice energy of barium chloride		
Enthalpy change of atomization of barium		180.0
Enthalpy change of atomization of $Cl_2(g)$ to 2Cl(g)		243.4
First ionization energy of barium		503
Second ionization energy of barium		965
	X	2 × (–348.8) = –697.6
Enthalpy change of formation of barium chloride		–858.6

(iii) Use the data to calculate the lattice energy of barium chloride.

(2)

Answer = ... kJ mol^{-1}

*(iv) Lattice energies can be calculated from electrostatic theory (theoretical values) as well as by Born-Haber cycles (experimental values).

What can you deduce from the fact that the experimental and theoretical values for the lattice energy of barium chloride are very close?

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(Total for Question 17 = 18 marks)

18 Lattice energy can be used as a measure of ionic bond strength. Born-Haber cycles can be used to determine experimental values of lattice energies.

The table below shows the energy changes that are needed to determine the lattice energy of lithium fluoride, LiF.

Energy change	ΔH / kJ mol^{-1}
Enthalpy change of atomization of lithium	+159
First ionization energy of lithium	+520
Enthalpy change of atomization of fluorine, $\frac{1}{2}F_2$	+79
First electron affinity of fluorine	−328
Enthalpy change of formation of lithium fluoride	−616

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

(2)

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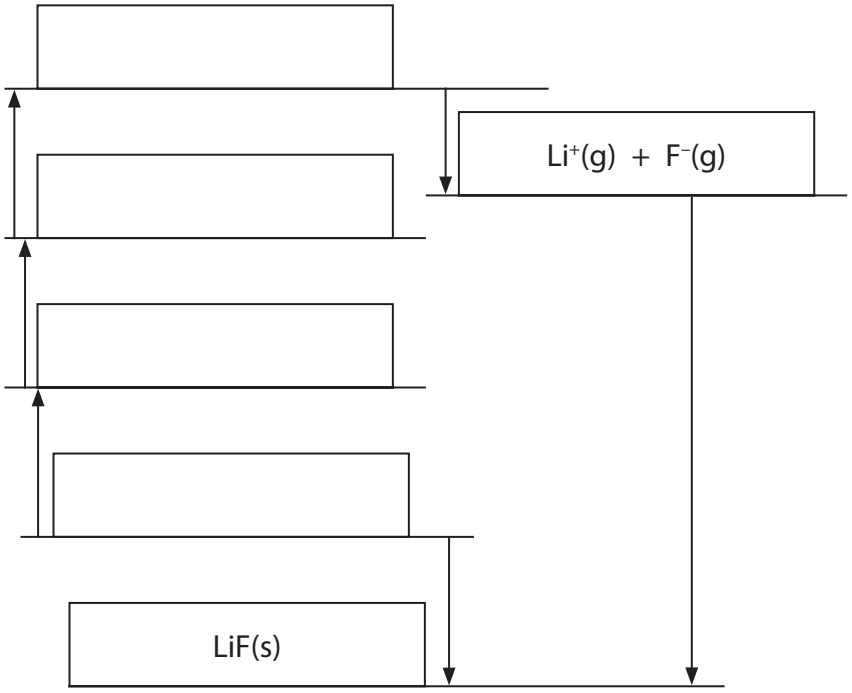
(b) The diagram below shows an incomplete Born-Haber cycle for the formation of lithium fluoride from lithium and fluorine.

(i) Complete the diagram by writing the formulae of the correct species, including state symbols, in the four empty boxes.

(4)



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

(2)

lattice energy = ... kJ mol^{-1}

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

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	–918
Sodium chloride, NaCl	–780
Magnesium fluoride, MgF_2	–2957

Explain, in terms of the sizes and charges of the ions involved, the differences between the lattice energy values of

(i) NaF and NaCl

(2)

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(ii) NaF and MgF_2

(2)

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(Total for Question 18 = 12 marks)