

## Learner resource 2 – Why do ions form?

### *Instructions and answers for teachers*

This Learner resource should be used in conjunction with the KS4–5 A Level Chemistry Transition Guide Bonding and Structure, which supports OCR A Level Chemistry A and Chemistry B (Salters).

These instructions cover the student activity section which can be found on [page 3](#). This Lesson Element supports OCR AS and A Level Chemistry A and Chemistry B (Salters).

**When distributing the activity section to the students either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

### Answers and teaching notes:

You may wish to demonstrate the formation of magnesium oxide and sodium chloride as a way to engage the learners; alternatively there are several good clips on YouTube. This worksheet assumes learners have not studied Born–Haber cycles as this is generally introduced in the second year of A Level study, if at all. Learners should, however, know that forming bonds is an exothermic process and that these changes have a negative sign (and vice versa).

1. Account for the difference in energy between the formation of the  $\text{Na}^+$  ion and the formation of the  $\text{Mg}^+$  ion.

Magnesium has one more proton on its nucleus; greater effective nuclear charge with the same shielding effect means the outer electron requires more energy to remove.

2. Why is the energy required to form the  $\text{Mg}^{2+}$  ion more than double the energy required to form the  $\text{Mg}^+$  ion?

Removal of the second electron requires more energy. After the first electron is lost, remaining electrons are pulled closer to the nucleus – the attraction increases. More energy is needed to overcome this increased attraction.

3. Calculate the total energy change involved in the electron transfer that occurs when sodium chloride forms from sodium and chlorine. Is this process endothermic or exothermic?

+147  $\text{kJ mol}^{-1}$ ; endothermic.

# CHEMISTRY A AND CHEMISTRY B (SALTERS)

## Teacher Instructions

4. The reaction between sodium and chlorine is very exothermic. How could you explain this?

A large amount of energy is released when the ionic lattice forms.

5. Explain why the formation of the  $O^{2-}$  ion is endothermic, whereas the formation of the  $O^{-}$  ion is exothermic.

The first electron added is attracted to the nucleus and so energy is released. The second electron is added to a negatively charged, very electron-dense ion and so energy is required to overcome the electrostatic repulsion.

6. What would be the overall energy change associated with:

- a. The formation of an  $Mg^{+}$  ion and an  $O^{-}$  ion

+596 kJ mol<sup>-1</sup>

- b. The formation of an  $Mg^{2+}$  ion and an  $O^{2-}$  ion

+2892 kJ mol<sup>-1</sup>

7. What are the charges on the magnesium and oxide ions in magnesium oxide?

$Mg^{2+}$  and  $O^{2-}$

8. Can the charges that form be explained by the energy changes associated with electron transfer?

No – electron transfer alone would suggest that only 1+ and 1– ions would form as this is less endothermic.

9. Is the formation of magnesium oxide an exothermic or endothermic process? Why do you think this is?

Exothermic – the energy required to form the ions is more than compensated for by the very large amount of energy released when the ionic lattice forms.

10. Why do you think sodium chloride does not have the formula  $NaCl_2$ ? Answer in terms of the energy changes associated with ion formation.

Formation of two  $Cl^{-}$  ions would release more energy than the formation of one. However, the energy required to form an  $Na^{2+}$  ion would be extremely large and would not be compensated for by the energy released when the ionic lattice forms.

## Learner resource 1 – Electron Transfer versus Ionic Bond Formation

### *Student Activity*

Formula of cation	Energy change when ion formed / $\text{kJ mol}^{-1}$	Formula of anion	Energy change when ion formed / $\text{kJ mol}^{-1}$
$\text{Na}^+$	+496	$\text{Cl}^-$	-349
$\text{Na}^{2+}$	+5060	$\text{Br}^-$	-324
$\text{Mg}^+$	+738	$\text{O}^-$	-142
$\text{Mg}^{2+}$	+2190	$\text{O}^{2-}$	+702

Use the information in the table to answer the questions that follow.

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AS and A LEVEL

# ***CHEMISTRY A AND CHEMISTRY B (SALTERS)***

## **Student Activity**