

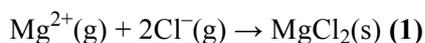
# F325: Equilibria, Energetics and Elements

## 5.2.1 Lattice Enthalpy

1. (a) (i)  $\text{Ca}^+$  is smaller than Ca/ proton : electron ratio in  $\text{Ca}^+ > \text{Ca}$  (1)  
greater attraction from nucleus (1) 2
- (ii) “oxide” ion,  $\text{O}^-$  and electron are both negative (1)  
hence energy is required to overcome repulsion (1) 2
- (b) completes Born-Haber cycle showing 1st IE $\uparrow$  2nd IE $\uparrow$  1st EA  $\downarrow$  2<sup>nd</sup> EA $\uparrow$   
and LE $\downarrow$ (1)(1)(1) (lose 1 mark for each error/omission)  
LE = -(1)3451 kJ mol<sup>-1</sup> (1) 5
- (c) differences in size of lattice enthalpies linked to ionic sizes/attraction  
using **more/less exothermic** rather than bigger or smaller. (1)  
 $\text{Mg}^{2+}$  is smaller/ $\text{Mg}^{2+}$  has greater charge density(1)  
hence has stronger attraction for  $\text{O}^{2-}$  (1) 3

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### 2. Definition – maximum 3 marks



The enthalpy change that accompanies the formation of one mole of a solid (compound) (1);  
from its constituent gaseous ions (1)

*Allow marks from an equation*

*Allow energy released / energy change*

*Not energy required*

*Allow ionic compound / salt*

### Born-Haber cycle – maximum 5 marks

Correct formulae on cycle (1)

Correct state symbols (1)

Use of 2 moles of  $\text{Cl}(\text{g})$  ie 246 (1)

Use of 2 moles of  $\text{Cl}^-(\text{g})$  i.e. 698 (1)

-2526 kJ mol<sup>-1</sup> (1)

*Every formula must have the correct state symbol at least once*

*Allow -2403 / -2875 (2)*

*Allow -2752 (1)*

*Unit required*

**Comparison – maximum 3 marks**

**Any three from**

Na<sup>+</sup> has a larger radius than Mg<sup>2+</sup> / ora (1)

Br<sup>-</sup> has a larger radius than Cl<sup>-</sup> / ora (1)

Na<sup>+</sup> has a lower charge than Mg<sup>2+</sup> / ora (1)

Strongest attraction is between Mg<sup>2+</sup> and Cl<sup>-</sup> / MgCl<sub>2</sub> has the strongest attraction between its ions / ora (1)

*Penalise the use of incorrect particle only once within the answer.*

*Penalise it the first time an incorrect particle is mentioned*

**Or**

Na<sup>+</sup> has a lower charge density than Mg<sup>2+</sup> / ora (1)

Br<sup>-</sup> has a lower charge density than Cl<sup>-</sup> / ora (1)

Strongest attraction between ions which have the highest charge density / MgCl<sub>2</sub> has the strongest attraction between its ions / ora (1)

**And QWC**

One mark for correct spelling, punctuation and grammar in at least two sentences (1)

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3. (a) (i) Ionisation energy refers to removing electrons that are attracted to the nucleus / energy needed to overcome the force of attraction between outer electrons and nucleus (1) 1
- (ii) Electron affinity involves an electron (being gained) experiencing attraction to the nucleus (1) 1
- (b) (i) Correct state symbols (1);  
*Allow 1 error or omission in state symbols.  
Providing formula has correct state symbols once in cycle this is sufficient*  
Correct formula (1);  
Correct cycle with labelling or energy values (1) 3
- (ii) = +178 + 249 + 798 + (-141) + 1150 + 590 + (-3459) (1)  
= -635 kJ mol<sup>-1</sup> (1) 2  
*Final answer must have correct units  
+635 kJ mol<sup>-1</sup> scores 0*

- (iii) Ionic radius of iron(II) less (than that of calcium ion) /  
charge density of  $\text{Fe}^{2+}$  greater (than that of  $\text{Ca}^{2+}$ ) / ora (1) 1

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4. (a) Atomisation of Na =  $(+)218 / 2 \times (+) 109$  (1);  
Ionisation of Na =  $(+)990 / 2 \times (+)495$  (1);  
Any other two correct enthalpy changes (1);  
Last two correct enthalpy change (1) 4

- (b)  $-791 + 141 - 247 - 990 - 218 - 416$  (1);  
 $-2521$  (1) 2

*Allow ecf from part (a) e.g.  $-2026$  if only 1 mole of  $\text{Na} \rightarrow \text{Na}^+$   
 $-2412$  if only 1 mole of  
 $\text{Na (s)} \rightarrow \text{Na (g)}$   
 $-1917$  if only 1 mole of Na throughout  
Allow full marks for  $-2521$  with no working out*

- (c) Calcium chloride (1)  
*If wrong salt chosen maximum of 2 marks (the comparison of  
the ions)*

And

$\text{Br}^-$  has larger ionic radius than  $\text{Cl}^-$  /  $\text{Br}^-$  has lower charge  
density than  $\text{Cl}^-$  / ora (1);  
*Not Br has larger radius*

$\text{K}^+$  has a lower charge than  $\text{Ca}^{2+}$  /  $\text{K}^+$  has lower charge  
density than  $\text{Ca}^{2+}$  /  $\text{K}^+$  has a larger ionic radius than  $\text{Ca}^{2+}$  / ora (1);  
*Not K has lower charge*  
*Not  $\text{K}^+$  has larger atomic radius*

Strongest attraction between ions (when smallest radius and  
highest charge) / strongest attraction between ions (with the  
highest charge density) / ora (1) 4

*Penalise use of atoms rather than ions just once in this question*

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5. (a) (i) Electron affinity -696 (1 mark);  
 Atomisation of  $Cl_2$  +244 (1 mark);  
 From top to bottom  
 $2^{nd}$  IE +1150,  
 $1^{st}$  IE +590,  
 atomisation of Ca +178  
 formation -796 (1 mark) 3  
*Allow 244, 1150, 590 and 176 i.e. without plus sign*
- (ii) -796 - 178 - 590 - 1150 - 244 + 696 (1);  
**But**  
 -2262 (with no working) (2) 2  
*Allow ecf from the wrong figures on the Born-Haber cycle*  
*1 error max one mark*  
*2 errors 0 mark*
- (iii) Magnesium fluoride more exothermic than calcium chloride / ora  
*Answer must refer to the correct particle.*  
 because  
 Ionic radius of  $Mg^{2+}$  is less than that of  $Ca^{2+}$  / charge density  
 of magnesium ion is greater than that of calcium ion / ora (1);  
 Ionic radius of  $F^-$  is less than that of  $Cl^-$  / charge density  
 of fluoride ion is greater than that of chloride ion / ora (1);  
*Not Mg or magnesium has a smaller radius or fluorine has a  
 smaller radius*  
 Stronger (electrostatic) attraction between cation and anion  
 in  $MgF_2$  than in  $CaCl_2$  / stronger ionic bonds in  $MgF_2$  (1) 3  
*Allow magnesium or fluorine has a smaller ionic radius*
- (b) **Any two from**  
 For second ionisation energy the electron lost is closer to the nucleus / AW (1);  
 For second ionisation energy the electron is lost from a particle that  
 is already positive (1);  
 For second ionisation energy there is one more proton than electron (1)  
 So outer electron more firmly attracted to the nucleus (1) 2  
*Allow ora*

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