

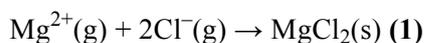
F325: Equilibria, Energetics and Elements

5.2.1 Lattice Enthalpy

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

[12]

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⁻¹ (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⁺ has a larger radius than Mg²⁺ / ora (1)

Br⁻ has a larger radius than Cl⁻ / ora (1)

Na⁺ has a lower charge than Mg²⁺ / ora (1)

Strongest attraction is between Mg²⁺ and Cl⁻ / MgCl₂ 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⁺ has a lower charge density than Mg²⁺ / ora (1)

Br⁻ has a lower charge density than Cl⁻ / ora (1)

Strongest attraction between ions which have the highest charge density / MgCl₂ 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)

12

[12]

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⁻¹ (1) 2
*Final answer must have correct units
+635 kJ mol⁻¹ scores 0*

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

[8]

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

Br^- has larger ionic radius than Cl^- / Br^- has lower charge
density than Cl^- / ora (1);
Not Br has larger radius

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

[10]

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

[10]