

Lattice energy - 2021

1. Nov/2020/Paper_41/No.2

(a) The lattice energies of three ionic compounds are given.

compound	lattice energy / kJ mol ⁻¹
LiF(s)	-1022
CaO(s)	-3513
SrO(s)	-3310

- Bond formation is an exothermic reaction.
Lattice energy is exothermic.

(i) Define the term *lattice energy*.

Its the energy released when 1 mole of an ionic compound is formed from its gaseous ions. [2]

(ii) Explain why the lattice energy of CaO is more exothermic than the lattice energy of LiF.

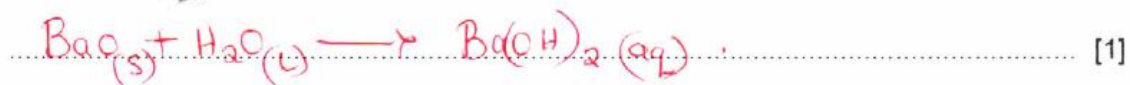
Lattice energy is dependent on charge. Ca²⁺ and O²⁻ have a higher charge density than Li⁺ and F⁻. [1]

(iii) Use the data in the table to estimate approximate values for the lattice energies of magnesium oxide and barium oxide.

$$\Delta H_{\text{lat}} \text{MgO(s)} = -3600 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{lat}} \text{BaO(s)} = -3200 \text{ kJ mol}^{-1}$$

(b) (i) Write an equation for the reaction between BaO and H₂O. Include state symbols.



(ii) State and explain how the solubilities of the hydroxides of the Group 2 elements vary down the group.

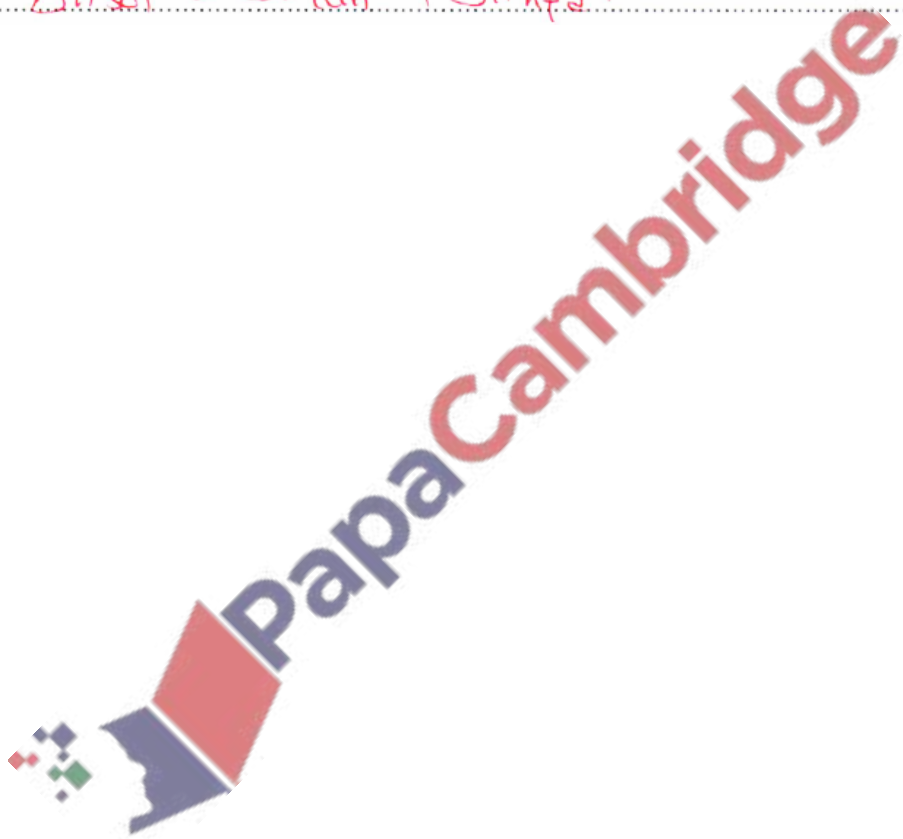
- Solubility of hydroxides increases down the group.

- Both ΔH_{lat} and ΔH_{hyd} become less exothermic

- ΔH_{lat} is more negative making ΔH_{sol} more exothermic.

$$\Delta H_{\text{sol}} = -\Delta H_{\text{lat}} + \Delta H_{\text{hyd}}$$

[4]

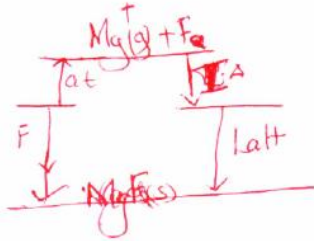


- (c) Use the following data and relevant data from the *Data Booklet* to calculate a value for the lattice energy of magnesium fluoride, $\text{MgF}_2(\text{s})$.

You might find it helpful to construct an energy cycle.
Show your working.

electron affinity of $\text{F}(\text{g}) = -348 \text{ kJ mol}^{-1}$
 enthalpy change of atomisation of $\text{Mg}(\text{s}) = +147 \text{ kJ mol}^{-1}$
 enthalpy change of formation of $\text{MgF}_2(\text{s}) = -1102 \text{ kJ mol}^{-1}$

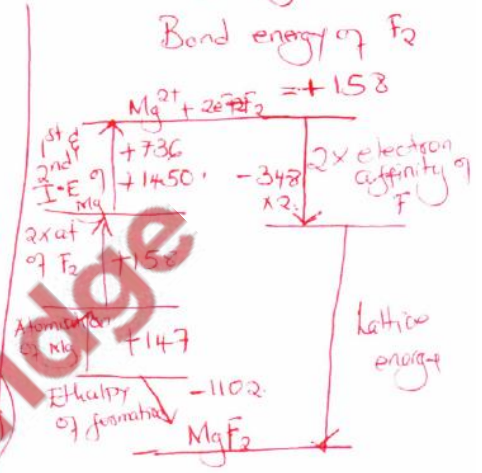
First ionisation of $\text{Mg} = +736$
 Second ionisation of $\text{Mg} = +1450$
 Bond energy of $\text{F}_2 = +158$



$$= -1102 - (+147 + (2 \times 348) + 158 + 736 + 1450)$$

$$= -2897$$

$$\Delta H_{\text{latt}} = \Delta H_{\text{formation}} - (\text{At of Mg} + \text{At of F}_2 + \text{I.E. of Mg} + \text{Electron affinity of F})$$



$$\Delta H_{\text{latt}} \text{MgF}_2(\text{s}) = -2897 \dots [3]$$

- (d) (i) Define the term *electron affinity*.

It's the energy change when 1 mole of electron is added to an atom or ion in gaseous atoms or ions. [2]

- (ii) The electron affinity of carbon, $\text{C}(\text{g})$, is -120 kJ mol^{-1} .

Suggest an explanation for the difference between the electron affinity of fluorine and the electron affinity of carbon.

Fluorine has a greater nuclear charge than carbon. It therefore has a greater attraction.

[1]

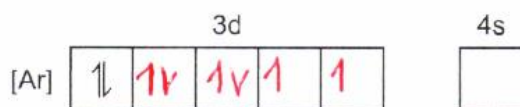
[Total: 15]

$$Ni = 28$$

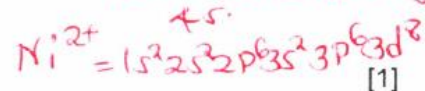
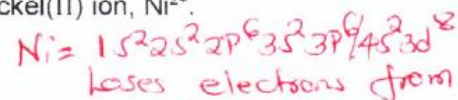
$$Ni^{2+} = 26$$

$$\frac{28}{13}$$

- (a) Complete the electronic configuration of an isolated gaseous nickel(II) ion, Ni^{2+} .



- Fill the orbitals singly before pairing electrons



- (b) Explain the origin of colour in transition element complexes.

d-orbitals split into two sets. An increase in energy causes the electron to absorb energy and jump to a higher d-orbital. absorbed energy is in a particular frequency of the visible spectrum thus forming coloured compounds.

[4]

- (c) Hexaaquanickel(II) ions are green. They form a green precipitate with hydroxide ions, OH^- , in equilibrium 1 and a blue complex with ammonia, NH_3 , in equilibrium 2.



Use Le Chatelier's principle to suggest explanations for the following observations.

- (i) Explain why when aqueous NH_3 is added dropwise to $[Ni(H_2O)_6]^{2+}$ a green precipitate is formed.

Addition of NH_3 increases the concentration of OH^- due to ligand exchange causing equilibrium 1 to shift to the right forming $Ni(OH)_2$

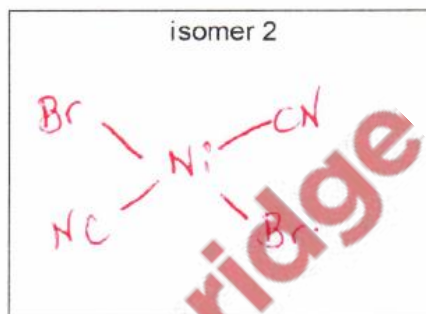
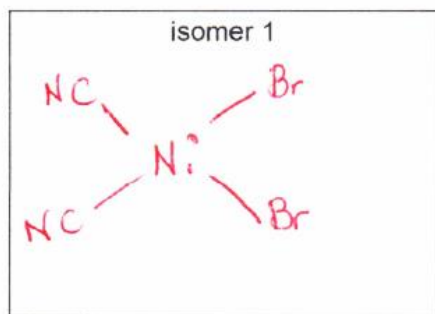
[1]

- (ii) Explain why when a large excess of aqueous NH_3 is added to $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, the green precipitate dissolves and a blue solution is formed.

Excess of NH_3 causes the equilibrium to shift to the right forming $[\text{Ni}(\text{NH}_3)_6]^{2+}$ which is blue. [1]

- (d) The complex ion $[\text{NiBr}_2(\text{CN})_2]^{2-}$ shows stereoisomerism.

Draw diagrams to show the two isomers of $[\text{NiBr}_2(\text{CN})_2]^{2-}$. Name the type of stereoisomerism.



type of stereoisomerism ... Cis-trans Isomerism / Geometric Isomerism

[2]

[Total: 9]



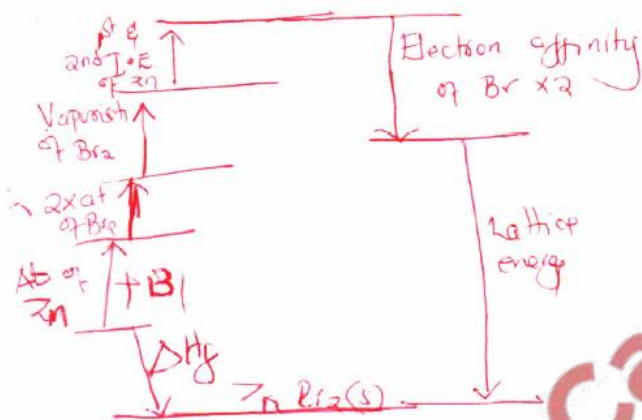
- (b) Use the following data and relevant data from the *Data Booklet* to calculate a value for the enthalpy change of formation of zinc bromide, $\text{ZnBr}_2(\text{s})$.

You might find it helpful to construct an energy cycle.

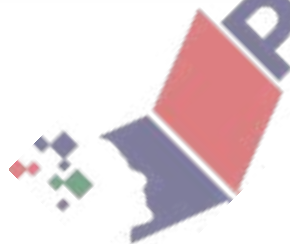
electron affinity of $\text{Br}(\text{g})$	$= -325 \text{ kJ mol}^{-1}$
enthalpy change of atomisation of $\text{Zn}(\text{s})$	$= +131 \text{ kJ mol}^{-1}$
enthalpy change of vaporisation of $\text{Br}_2(\text{l})$	$= +31 \text{ kJ mol}^{-1}$
lattice energy of $\text{ZnBr}_2(\text{s})$	$= -2678 \text{ kJ mol}^{-1}$

$$\Delta H_f^\ominus = \text{Atomisation of Zn} + \text{Vaporisation of Br}_2 + \text{Electron affinity of Br(g)} + \text{Lattice energy}$$

$$+131 + (908 + 1730) + 193 + 31 + (2 \times -325) + (-2678)$$



enthalpy change of formation of $\text{ZnBr}_2(\text{s}) = \dots\dots\dots -335 \dots\dots\dots \text{ kJ mol}^{-1}$ [4]



(c) The lattice energies of ZnBr_2 , ZnCl_2 and ZnO are shown.

compound	lattice energy / kJ mol^{-1}
ZnBr_2	-2678
ZnCl_2	-2734
ZnO	-3971

(i) Explain why there is a difference between the lattice energies of ZnBr_2 and ZnCl_2 .

Br^- is larger than Cl^- . The attraction between Zn and Br is low. [1]

(ii) Explain why there is a difference between the lattice energies of ZnCl_2 and ZnO .

O^{2-} is a smaller ion since it has a greater charge as compared to chlorine. [1]

The attraction between zinc and O^{2-} is greater. [Total: 10]



PapaCambridge