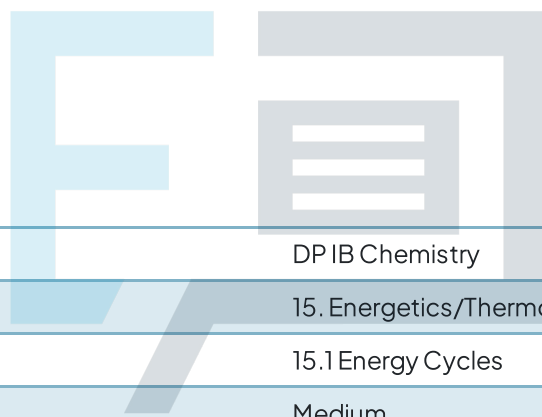




15.1 Energy Cycles

Mark Schemes



Course	DP IB Chemistry
Section	15. Energetics/Thermochemistry (HL only)
Topic	15.1 Energy Cycles
Difficulty	Medium

Exam Papers Practice

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

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The correct answer is **B** because:

- Formula is MgO
- $\Delta H_f^\ominus(\text{MgO}) = \Delta H_{\text{at}}^\ominus(\text{Mg}) + \Delta H_{\text{IE1}}^\ominus(\text{Mg}) + \Delta H_{\text{IE2}}^\ominus(\text{Mg}) + \Delta H_{\text{at}}^\ominus(\text{O}) + \Delta H_{\text{EA1}}^\ominus(\text{O}) + \Delta H_{\text{EA2}}^\ominus(\text{O}) + \Delta H_{\text{latt}}^\ominus(\text{MgO})$
- $\Delta H_{\text{latt}}^\ominus(\text{MgO}) = \Delta H_f^\ominus(\text{MgO}) - \Delta H_{\text{at}}^\ominus(\text{Mg}) - \Delta H_{\text{IE1}}^\ominus(\text{Mg}) - \Delta H_{\text{IE2}}^\ominus(\text{Mg}) - \Delta H_{\text{at}}^\ominus(\text{O}) - \Delta H_{\text{EA1}}^\ominus(\text{O}) - \Delta H_{\text{EA2}}^\ominus(\text{O})$
- $\Delta H_{\text{latt}}^\ominus(\text{MgO}) = -602 - 150 - 2188 - 248 - 702$
- $\Delta H_{\text{latt}}^\ominus(\text{MgO}) = -3890 \text{ kJ mol}^{-1}$

A is incorrect as	the value for $\Delta H_{\text{EA1}}^\ominus(\text{O})$ and $\Delta H_{\text{EA2}}^\ominus(\text{O})$ should be subtracted, not added
C is incorrect as	the value for $\Delta H_{\text{at}}^\ominus(\text{O})$ has been used incorrectly for the final calculation, i.e. -248 should be used, not $-(\frac{248}{2})$ The value only needs to be divided by 2 if the bond enthalpy of oxygen is used for magnesium oxide
D is incorrect as	the value for $\Delta H_{\text{at}}^\ominus(\text{O})$ has been used incorrectly for the final calculation, i.e. -248 should be used, not $-(248 \times 2)$ The value only needs to be multiplied by 2 if the enthalpy of atomisation is used and there are 2 moles required (e.g. MgCl_2)

Tip: It can be easy to get lost in all the ΔH terms, it can be easier to put the numbers in and simplify the expression before rearranging, e.g.

$$\begin{aligned} \Delta H_f^\ominus(\text{MgO}) &= \Delta H_{\text{at}}^\ominus(\text{Mg}) + \Delta H_{\text{IE1}}^\ominus(\text{Mg}) + \Delta H_{\text{IE2}}^\ominus(\text{Mg}) + \\ &\Delta H_{\text{at}}^\ominus(\text{O}) + \Delta H_{\text{EA1}}^\ominus(\text{O}) + \\ &\quad \Delta H_{\text{EA2}}^\ominus(\text{O}) + \Delta H_{\text{latt}}^\ominus(\text{MgO}) \\ -602 &= 150 + 2188 + 248 + 702 + \Delta H_{\text{lat}}^\ominus(\text{MgO}) \\ -602 &= 3288 + \Delta H_{\text{lat}}^\ominus(\text{MgO}) \\ \Delta H_{\text{lat}}^\ominus(\text{MgO}) &= -602 - 3288 \end{aligned}$$

2

The correct answer is **C** because:

- The correct equation to calculate the $\Delta H_{\text{sol}}^\ominus$ is:
 - $\Delta H_{\text{sol}}^\ominus = \Delta H_{\text{latt}}^\ominus + (\Sigma \Delta H_{\text{hyd}}^\ominus)$
 - $\Delta H_{\text{sol}}^\ominus = +2651 + [-1616 + (2 \times -504)]$
 - $\Delta H_{\text{sol}}^\ominus = +2651 + [(-1616) + (-1008)]$
- $(\Sigma \Delta H_{\text{hyd}}^\ominus)$ must be for all the ions that are present, in CaF_2 , there are two F^- ions, so the value must be doubled

A is incorrect as	The value for $\Delta H_{\text{hyd}}^\ominus \text{F}^-$ has not been multiplied by 2
B is incorrect as	$\Delta H_{\text{sol}}^\ominus = \Delta H_{\text{latt}}^\ominus - (\Sigma \Delta H_{\text{hyd}}^\ominus)$ has been used rather than $\Delta H_{\text{sol}}^\ominus = \Delta H_{\text{latt}}^\ominus + (\Sigma \Delta H_{\text{hyd}}^\ominus)$ and the value for $\Delta H_{\text{hyd}}^\ominus \text{F}^-$ has not been multiplied by 2
D is incorrect as	$\Delta H_{\text{sol}}^\ominus = \Delta H_{\text{latt}}^\ominus - (\Sigma \Delta H_{\text{hyd}}^\ominus)$ has been used rather than $\Delta H_{\text{sol}}^\ominus = \Delta H_{\text{latt}}^\ominus + (\Sigma \Delta H_{\text{hyd}}^\ominus)$

3

The correct answer is **C** because:

- Lattice enthalpy depends upon two factors
 - Ionic radius: As the distance between the bonded ions increases, the strength of the electrostatic attraction decreases
 - Ionic charge: Increasing the ionic charge will result in an increased attraction between oppositely charged ions
- Beryllium oxide, BeO , has a Be ion with a +2 charge which is also the smallest cation from the options, the lattice enthalpy will be the greatest

A is incorrect as	potassium, K^+ , has a smaller charge and greater ionic radius than Be^{2+}
B is incorrect as	calcium, Ca^{2+} , has greater ionic radius than Be^{2+}
D is incorrect as	silver, Ag^+ , has a smaller charge and greater ionic radius than Be^{2+} Br^- also has a larger ionic radius than O^{2-}

4

The correct answer is **B** because:

- This change is the first electron affinity of chlorine, $\Delta H_{EA1}^{\ominus}Cl$
- The electron affinity of an element is the energy change when 1 mole of electrons is gained by 1 mole of gaseous atoms of an element to form 1 mole of gaseous ions under standard conditions
- The first electron affinity is always exothermic as energy is released when electrons are attracted to the atoms

<p>A is incorrect as</p>	<p>this is the first ionisation energy of potassium, $\Delta H_{IE1}^{\ominus}K$.</p> <p>This change is endothermic as energy is need to overcome the attraction between an electron and the nucleus</p>
<p>C is incorrect as</p>	<p>this is the atomisation of calcium, $\Delta H_{at}^{\ominus}Ca$.</p> <p>This change is always endothermic as energy is always required to break any bonds between the atoms in the element or to break the element into its gaseous atoms</p>
<p>D is incorrect as</p>	<p>this is the second electron affinity of oxygen, $\Delta H_{EA2}^{\ominus}O$.</p> <p>The second electron affinity of an element can be endothermic because a large force of repulsion must be overcome between the negatively charged ion and the second electron requiring a large input of energy</p>

5

The correct answer is **B** because:

- Statements I and III are correct
- Statement I is correct because
 - Hydration enthalpies are the measure of the energy that is released when there is an attraction formed between the ions and water molecules
 - The lattice enthalpy is the change that occurs on the formation of gaseous ions from the solid lattice
 - If the reverse lattice enthalpy is greater than the hydration enthalpy the salt will be insoluble in water
 - If the reverse lattice enthalpy is less than the hydration enthalpy the salt will be soluble in water
- Statement II is incorrect because
 - Melting points of ionic compounds actually decrease as the size of the cation increases
 - This is due to the increased distance between the cation and anion
 - This therefore decreases the electrostatic attraction between the cations and anions
 - Therefore the lattice energy will decrease as less energy is required to separate the ions
- Statement III is correct because
 - This is the enthalpy change of solution when an ionic substance dissolves in water to give a solution
 - For calcium chloride this is represented by $\text{CaCl}_2(\text{s}) \rightarrow \text{CaCl}_2(\text{aq})$

A, C & D are incorrect as

statement II is incorrect