HL Paper 1

In which reaction will the entropy of the system increase significantly?

A. $\mathrm{CaCO_3(s) \rightarrow CaO(s) + CO_2(g)}$

B. $\mathrm{H_2O(g) \rightarrow H_2O(l)}$

C. $\mathrm{HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)}$

D. $\mathrm{NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)}$

Consider the values of ΔH^Θ and ΔS^Θ À for the reaction of nitrogen with oxygen at 298 K.

$$\mathrm{N_2(g) + O_2(g) \rightarrow 2NO(g)} \quad \Delta H^\Theta = +181\ \mathrm{kJ\,mol^{-1}}$$

$$\Delta S^\Theta = +25\ \mathrm{J\,K^{-1}mol^{-1}}$$

Which statement is correct for this reaction?

A. ΔG^Θ is positive at all temperatures.

B. ΔG^Θ is negative at all temperatures.

C. ΔG^Θ is positive at high temperatures.

D. ΔG^Θ is positive at low temperatures.

What is the standard enthalpy of formation, in kJ mol^{-1}, of IF (g)?

$$\mathrm{IF_7\ (g) + I_2\ (s) \rightarrow IF_5\ (g) + 2IF\ (g)} \qquad \Delta H^\theta = -89\ \mathrm{kJ}$$

ΔH_f^θ ($\mathrm{IF_7}$) = –941 kJ mol^{-1}

ΔH_f^θ ($\mathrm{IF_5}$) = –840 kJ mol^{-1}

A. –190

B. –95

C. +6

D. +95

Which is a correct definition of lattice enthalpy?

A. It is the enthalpy change that occurs when an electron is removed from 1 mol of gaseous atoms.

B. It is the enthalpy change that occurs when 1 mol of a compound is formed from its elements.

C. It is the enthalpy change that occurs when 1 mol of solid crystal changes into a liquid.

D. It is the enthalpy change that occurs when 1 mol of solid crystal is formed from its gaseous ions.

Which equation corresponds to the lattice enthalpy for silver iodide, AgI?

A. $\mathrm{AgI(s) \rightarrow Ag(s) + I(g)}$

B. $\mathrm{AgI(s) \rightarrow Ag(s) + \frac{1}{2}I_2(g)}$

C. $\mathrm{AgI(s) \rightarrow Ag^+(aq) + I^-(aq)}$

D. $\mathrm{AgI(s) \rightarrow Ag^+(g) + I^-(g)}$

Which reaction has the largest increase in entropy?

A. $\mathrm{H_2(g) + Cl_2(g) \rightarrow 2HCl(g)}$

B. $\mathrm{Al(OH)_3(s) + NaOH(aq) \rightarrow Al(OH)_4^-(aq) + Na^+(aq)}$

C. $\mathrm{Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)}$

D. $\mathrm{BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)}$

Which reaction has the greatest increase in entropy?

A. $\mathrm{SO_2(g) + 2H_2S(g) \rightarrow 2H_2O(l) + 3S(s)}$

B. $\mathrm{CaO(s) + CO_2(g) \rightarrow CaCO_3(s)}$

C. $\mathrm{CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)}$

D. $\mathrm{N_2(g) + O_2(g) \rightarrow 2NO(g)}$

Which equation represents enthalpy of hydration?

A. $\mathrm{Na(g) \rightarrow Na^+(aq) + e^-}$

B. $\mathrm{Na^+(g) \rightarrow Na^+(aq)}$

C. $\mathrm{NaCl(s) \rightarrow Na^+(g) + Cl^-(g)}$

D. $\mathrm{NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)}$

Which ionic compound has the most endothermic lattice enthalpy?

A. NaCl

B. KCl

C. NaF

D. KF

Which statement is correct?

A. If $\Delta H < 0$, reaction is always spontaneous.

B. If $\Delta H > 0$, reaction is never spontaneous.

C. If $\Delta S < 0$, reaction can be spontaneous if temperature is low enough.

D. If $\Delta S < 0$, reaction can be spontaneous if temperature is high enough.

Which step(s) is/are endothermic in the Born-Haber cycle for the formation of LiCl?

A. $\frac{1}{2}\mathrm{Cl_2(g)} \rightarrow \mathrm{Cl(g)}$ **and** $\mathrm{Li(s)} \rightarrow \mathrm{Li(g)}$

B. $\mathrm{Cl(g) + e^- \rightarrow Cl^-(g)}$ **and** $\mathrm{Li(g) \rightarrow Li^+(g) + e^-}$

C. $\mathrm{Li^+(g) + Cl^-(g) \rightarrow LiCl(s)}$

D. $\frac{1}{2}\mathrm{Cl_2(g)} \rightarrow \mathrm{Cl(g)}$ **and** $\mathrm{Cl(g) + e^- \rightarrow Cl^-(g)}$

Which ion's hydration energy is the most exothermic?

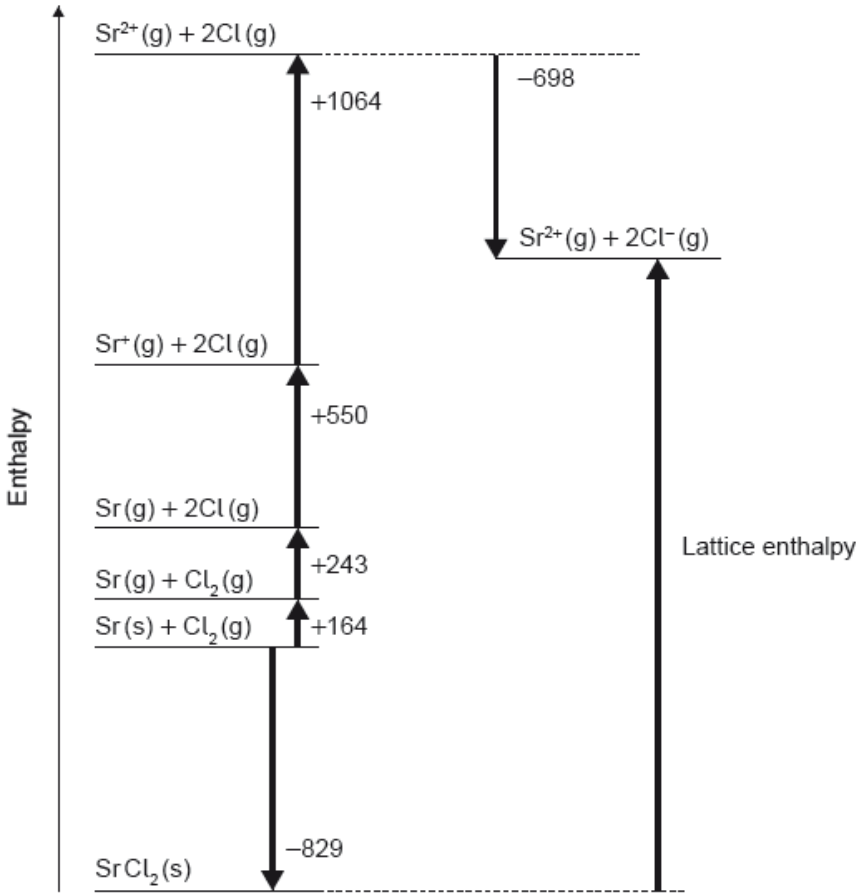
A. Li^+

B. Na^+

C. Br^-

D. I^-

Which value represents the lattice enthalpy, in kJ mol^{-1}, of strontium chloride, $SrCl_2$?



A. – (–829) + 164 + 243 + 550 + 1064 – (–698)

B. –829 + 164 + 243 + 550 + 1064 – 698

C. – (–829) + 164 + 243 + 550 + 1064 – 698

D. –829 + 164 + 243 + 550 + 1064 – (–698)

Which change will **not** increase the entropy of a system?

A. Increasing the temperature

B. Changing the state from liquid to gas

C. Mixing different types of particles

D. A reaction where four moles of gaseous reactants changes to two moles of gaseous products

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Which reaction has the greatest increase in entropy?

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

B. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

C. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

D. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

Which combination of ΔH and ΔS signs will always result in a spontaneous reaction at all temperatures?

	ΔH	ΔS
A.	+	+
B.	+	−
C.	−	−
D.	−	+

Which compound has the most positive lattice enthalpy of dissociation?

A. NaCl

B. NaBr

C. $\mathrm{MgCl_2}$

D. $\mathrm{MgBr_2}$

Which transition represents an enthalpy of hydration?

A. $2H_2O\ (l) \rightarrow H_3O^+\ (aq) + OH^-\ (aq)$
B. $NaCl\ (s) \rightarrow Na^+\ (aq) + Cl^-\ (aq)$
C. $K^+(s) \rightarrow K^+(aq)$
D. $K^+(g) \rightarrow K^+(aq)$

Which combination of ΔH and ΔS values corresponds to a non-spontaneous reaction at all temperatures?

	ΔH	ΔS
A.	−	−
B.	+	−
C.	−	+
D.	+	+

Which reactions/processes have a positive entropy change, $\Delta S^{\ominus}$?

I. $\mathrm{NaCl(s) \rightarrow NaCl(aq)}$

II. $\mathrm{Na_2CO_3(s) + 2HCl(aq) \rightarrow CO_2(g) + 2NaCl(aq) + H_2O(l)}$

III. $\mathrm{AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which change leads to an increase in entropy?

A. $\mathrm{CO_2(g) \rightarrow CO_2(s)}$

B. $\mathrm{SF_6(g) \rightarrow SF_6(l)}$

C. $\mathrm{H_2O(l) \rightarrow H_2O(s)}$

D. $\mathrm{NaCl(s) \rightarrow NaCl(aq)}$

Which ionic compound has the most endothermic lattice enthalpy?

A. Sodium chloride

B. Sodium oxide

C. Magnesium chloride

D. Magnesium oxide

Which factors will increase the entropy of this system?

$$\mathrm{CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)}$$

I. Increasing the temperature without changing the volume of the container.

II. Decreasing the concentration of the gas without changing the volume of the container.

III. Increasing the pressure without changing the volume of the container.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which system has the most negative entropy change, ΔS, for the forward reaction?

A. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C. $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

D. $H_2O(l) \rightarrow H_2O(g)$

Which change **must** be negative when a reaction occurs spontaneously?

A. ΔH

B. ΔG

C. ΔS

D. ΔT

Which statements are correct for ionic compounds?

I. Lattice energy increases as ionic radii increase.
II. Within the same group, the melting point of salts tends to decrease as the radius of the cation increases.
III. Solubility in water depends on the relative magnitude of the lattice energy compared to the hydration energy.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which processes have a negative value for ΔS^{Θ}?

I. $\mathrm{H_2O(l) \rightarrow H_2O(s)}$

II. $\mathrm{2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)}$

III. $\mathrm{2H_2(g) + O_2(g) \rightarrow 2H_2O(g)}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which processes are predicted to have a positive entropy change, ΔS?

I. $\mathrm{I_2(g) \rightarrow I_2(s)}$

II. $\mathrm{4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)}$

III. $\mathrm{CH_3OH(l) \rightarrow CH_3OH(g)}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which equation represents the lattice enthalpy of magnesium sulfide?

A. $MgS\ (s) \rightarrow Mg\ (g) + S\ (g)$

B. $MgS\ (s) \rightarrow Mg^{+}\ (g) + S^{-}\ (g)$

C. $MgS\ (s) \rightarrow Mg^{2+}\ (g) + S^{2-}\ (g)$

D. $MgS\ (s) \rightarrow Mg\ (s) + S\ (s)$

Which equation represents the second electron affinity of oxygen?

A. $\frac{1}{2}O_2(g) + 2e^- \rightarrow O^{2-}(g)$

B. $O(g) + 2e^- \rightarrow O^{2-}(g)$

C. $O_2(g) + 4e^- \rightarrow 2O^{2-}(g)$

D. $O^-(g) + e^- \rightarrow O^{2-}(g)$

Which combinations of values will result in a spontaneous reaction?

	ΔH / kJ mol^{-1}	ΔS / J K^{-1} mol^{-1}	T / K
I.	−100	−100	300
II.	+100	−100	300
III.	+100	+100	3000

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

What are the signs for the entropy changes associated with this reaction?

$$H_2O(g) \rightarrow H_2O(l)$$

	$\Delta S_{surroundings}$	ΔS_{system}
A.	+	–
B.	+	+
C.	–	–
D.	–	+

Which combination of ΔH^{θ} and ΔS^{θ} will result in a non-spontaneous reaction at all temperatures?

	$\Delta H^{\ominus}$	$\Delta S^{\ominus}$
A.	positive	negative
B.	negative	positive
C.	positive	positive
D.	negative	negative

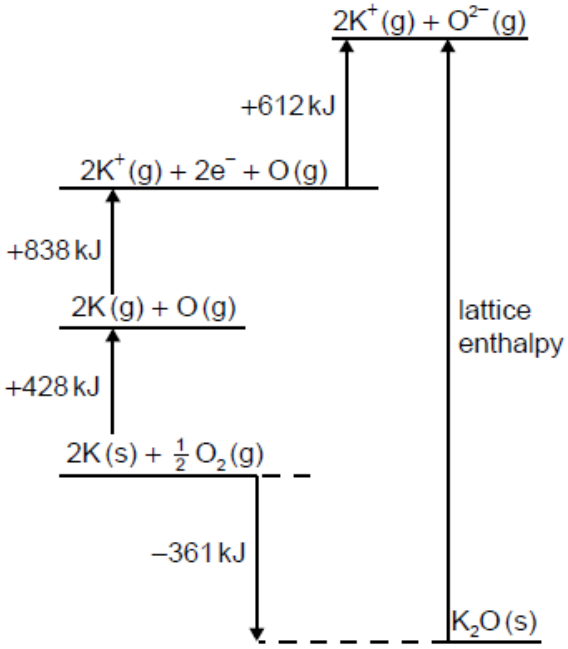
The combustion of glucose is exothermic and occurs according to the following equation:

$$C_6H_{12}O_6\ (s) + 6O_2\ (g) \rightarrow 6CO_2\ (g) + 6H_2O\ (g)$$

Which is correct for this reaction?

	$\Delta H^{\ominus}$	$\Delta S^{\ominus}$	**Spontaneous/ non-spontaneous**
A.	negative	positive	spontaneous
B.	negative	positive	non-spontaneous
C.	positive	negative	spontaneous
D.	positive	positive	non-spontaneous

The Born-Haber cycle for potassium oxide is shown below:



Which expression represents the lattice enthalpy in kJ mol^{-1}?

A. –361 + 428 + 838 + 612

B. –(–361) + 428 + 838 + 612

C. –361 + 428 + 838 – 612

D. –(–361) + 428 + 838 – 612

What is the correct order for **increasing** lattice enthalpy?

A. $\mathrm{MgO} < \mathrm{MgCl_2} < \mathrm{NaCl} < \mathrm{CsCl}$

B. $\mathrm{CsCl} < \mathrm{NaCl} < \mathrm{MgCl_2} < \mathrm{MgO}$

C. $\mathrm{NaCl} < \mathrm{CsCl} < \mathrm{MgO} < \mathrm{MgCl_2}$

D. $\mathrm{NaCl} < \mathrm{CsCl} < \mathrm{MgCl_2} < \mathrm{MgO}$

Consider the following information:

$$\mathrm{CaCO_3(s)} \rightarrow \mathrm{CaO(s)} + \mathrm{CO_2(g)}$$
$$\Delta H = +179\ \mathrm{kJ\,mol^{-1}}$$
$$\Delta S = +161.0\ \mathrm{J\,K^{-1}mol^{-1}}$$

What happens to the spontaneity of this reaction as the temperature is increased?

A. The reaction becomes more spontaneous as the temperature is increased.

B. The reaction becomes less spontaneous as the temperature is increased.

C. The reaction remains spontaneous at all temperatures.

D. The reaction remains non-spontaneous at all temperatures.

Which equation represents the lattice enthalpy of calcium chloride?

A. $\mathrm{CaCl(s) \rightarrow Ca^{+}(g) + Cl^{-}(g)}$

B. $\mathrm{CaCl_2(s) \rightarrow Ca^{2+}(g) + 2Cl^{-}(g)}$

C. $\mathrm{CaCl_2(g) \rightarrow Ca^{2+}(g) + 2Cl^{-}(g)}$

D. $\mathrm{CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2Cl^{-}(aq)}$

Which ionic compound has the greatest lattice enthalpy?

A. MgO

B. CaO

C. NaF

D. KF

A reaction has a standard enthalpy change, ΔH^{Θ}, of $+10.00\ \mathrm{kJ\,mol^{-1}}$ at 298 K. The standard entropy change, ΔS^{Θ}, for the same reaction is $+10.00\ \mathrm{J\,K^{-1}mol^{-1}}$. What is the value of ΔG^{Θ} for the reaction in $\mathrm{kJ\,mol^{-1}}$?

A. +9.75

B. +7.02

C. –240

D. –2970

Which process would be expected to have a ΔS^{Θ} value which is negative?

A. $\mathrm{2H_2(g) + O_2(g) \rightarrow 2H_2O(g)}$

B. $\mathrm{NaCl(s) \rightarrow Na^{+}(g) + Cl^{-}(g)}$

C. $\mathrm{H_2(g) + I_2(g) \rightarrow 2HI(g)}$

D. $\mathrm{OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)}$

The reaction between but-1-ene and water vapour produces butan-1-ol.

$$\mathrm{C_4H_8(g) + H_2O(g) \rightarrow C_4H_9OH(l)}$$

The standard entropy values (S^{Θ}) for but-1-ene, water vapour and butan-1-ol are 310, 189 and $228\ \mathrm{J\,K^{-1}mol^{-1}}$ respectively. What is the standard entropy change for this reaction in $\mathrm{J\,K^{-1}mol^{-1}}$?

A. –271

B. +271

C. −107

D. +107

Which combination of enthalpy change and entropy change produces a non-spontaneous reaction at **all** temperatures?

	ΔH	ΔS
A.	+	−
B.	+	+
C.	−	−
D.	−	+

When hydrogen peroxide decomposes, the temperature of the reaction mixture increases.

$$2\mathrm{H_2O_2(aq)} \rightarrow \mathrm{O_2(g)} + 2\mathrm{H_2O(l)}$$

What are the signs of ΔH, ΔS and ΔG for this reaction?

	ΔH	ΔS	ΔG
A.	−	−	−
B.	−	+	−
C.	+	+	−
D.	−	+	+

Which ionic compound has the largest value of lattice enthalpy?

A. MgS

B. MgO

C. $CaBr_2$

D. NaF

Which reaction has the greatest increase in entropy?

A. $2\mathrm{CH_3OH(l)} + 3\mathrm{O_2(g)} \rightarrow 2\mathrm{CO_2(g)} + 4\mathrm{H_2O(l)}$

B. $\mathrm{N_2(g)} + 3\mathrm{H_2(g)} \rightarrow 2\mathrm{NH_3(g)}$

C. $2\mathrm{HCl(aq)} + \mathrm{MgCO_3(s)} \rightarrow \mathrm{MgCl_2(aq)} + \mathrm{H_2O(l)} + \mathrm{CO_2(g)}$

D. $\mathrm{NH_3(g)} + \mathrm{HCl(g)} \rightarrow \mathrm{NH_4Cl(s)}$

Which species are arranged in order of **increasing** entropy?

A. $\mathrm{C_3H_8(g)} < \mathrm{CH_3OH(l)} < \mathrm{Hg(l)} < \mathrm{Na(s)}$

B. $\mathrm{CH_3OH(l)} < \mathrm{C_3H_8(g)} < \mathrm{Hg(l)} < \mathrm{Na(s)}$

C. $\mathrm{Na(s)} < \mathrm{Hg(l)} < \mathrm{CH_3OH(l)} < \mathrm{C_3H_8(g)}$

D. $\mathrm{Na(s)} < \mathrm{Hg(l)} < \mathrm{C_3H_8(g)} < \mathrm{CH_3OH(l)}$

Which equation represents the electron affinity of chlorine?

A. $\mathrm{Cl(g)} + \mathrm{e^-} \rightarrow \mathrm{Cl^-(g)}$

B. $\mathrm{Cl(g)} + \mathrm{e^-} \rightarrow \mathrm{Cl(g)}$

C. $\mathrm{Cl_2(g)} + 2\mathrm{e^-} \rightarrow 2\mathrm{Cl^-(g)}$

D. $\mathrm{Cl(g)} \rightarrow \mathrm{Cl^+(g)} + \mathrm{e^-}$

What is the correct definition of lattice enthalpy?

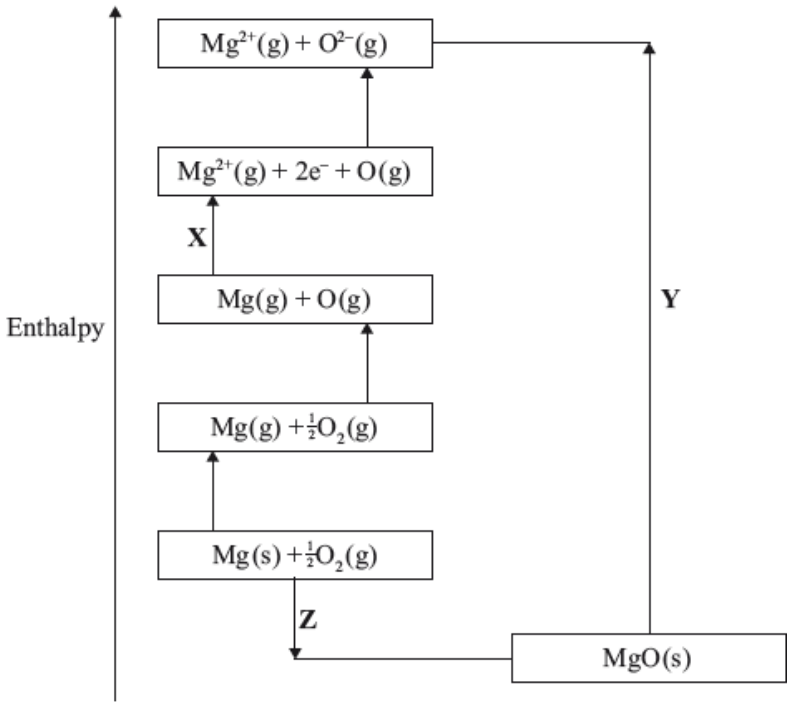
A. Enthalpy change when one mole of a solid ionic compound is separated into gaseous ions.

B. Enthalpy change when one mole of a solid ionic compound is separated into its ions in their standard state.

C. Enthalpy change when one mole of a solid ionic compound is formed from gaseous elements.

D. Enthalpy change when one mole of a compound is formed from the elements in their standard states.

The Born-Haber cycle for the formation of magnesium oxide is shown below.



What is a correct description of the steps **X**, **Y** and **Z** in this cycle?

	Step X	Step Y	Step Z
A.	2nd ionization energy of Mg	enthalpy of formation of MgO	lattice enthalpy of MgO
B.	2nd ionization energy of Mg	lattice enthalpy of MgO	enthalpy of formation of MgO
C.	sum of the 1st and 2nd ionization energies of Mg	lattice enthalpy of MgO	enthalpy of formation of MgO
D.	sum of 1st and 2nd ionization energies of Mg	enthalpy of formation of MgO	lattice enthalpy of MgO

Which combination of ions will give the greatest absolute lattice enthalpy?

A. A small positive ion with a high charge and a small negative ion with a high charge

B. A small positive ion with a low charge and a small negative ion with a low charge

C. A large positive ion with a high charge and a large negative ion with a high charge

D. A large positive ion with a low charge and a small negative ion with a low charge

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The rate expression for the reaction between iodine and propanone with an acid catalyst is found to be:

$$\text{rate} = k[\text{H}^+]^1[\text{I}_2]^0[\text{CH}_3\text{COCH}_3]^1$$

What is the overall order of the reaction?

A. 0

B. 1

C. 2

D. 3

ΔG^{Θ} calculations predict that a reaction is always spontaneous for which of the following combinations of ΔH^{Θ} and ΔS^{Θ}?

A. $+\Delta H^{\Theta}$ and $+\Delta S^{\Theta}$

B. $+\Delta H^{\Theta}$ and $-\Delta S^{\Theta}$

C. $-\Delta H^{\Theta}$ and $-\Delta S^{\Theta}$

D. $-\Delta H^{\Theta}$ and $+\Delta S^{\Theta}$

Which row of the table correctly represents the equations for the lattice enthalpy of substance XY and the electron affinity of atom Y?

	Lattice enthalpy	Electron affinity
A.	$X^+(g) + Y^-(g) \rightarrow XY(g)$	$Y^-(g) + e^- \rightarrow Y^{2-}(g)$
B.	$X^+(g) + Y^-(g) \rightarrow XY(s)$	$Y(g) + e^- \rightarrow Y^-(g)$
C.	$X^+(g) + Y^-(g) \rightarrow XY(s)$	$Y(s) + e^- \rightarrow Y^-(s)$
D.	$X^+(g) + Y^-(g) \rightarrow XY(g)$	$Y(g) + e^- \rightarrow Y^-(g)$

What is the standard entropy change, ΔS^{Θ}, for the following reaction?

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

	$CO(g)$	$O_2(g)$	$CO_2(g)$
S^{Θ} / J K^{-1} mol^{-1}	198	205	214

A. –189

B. –173

C. +173

D. +189

What is the enthalpy of solution of $MgF_2(s)$ in kJ mol^{-1}?

Lattice enthalpy of $MgF_2(s)$ = 2926 kJ mol^{-1}

Hydration enthalpy of $Mg^{2+}(g)$ = –1963 kJ mol^{-1}

Hydration enthalpy of $F^-(g)$ = –504 kJ mol^{-1}

A. 2926 – 1963 + 2(–504)

B. 2926 – 1963 – 504

C. –2926 – (–1963) – (–504)

D. –2926 – (–1963) – 2(–504)

When solid potassium chlorate, $\mathrm{KClO_3}$, dissolves in distilled water the temperature of the solution decreases. What are the signs of ΔH^{Θ}, ΔS^{Θ} and ΔG^{Θ} for this spontaneous process?

	ΔH^{Θ}	ΔS^{Θ}	ΔG^{Θ}
A.	+	+	+
B.	+	+	–
C.	–	–	–
D.	+	–	+

Which represents the enthalpy change of hydration of the chloride ion?

A. $Cl^-(g) \xrightarrow{H_2O} Cl^-(aq)$

B. $Cl(g) \xrightarrow{H_2O} Cl^-(aq)$

C. $\frac{1}{2}Cl_2(g) \xrightarrow{H_2O} Cl^-(aq)$

D. $\frac{1}{2}Cl_2(aq) \xrightarrow{H_2O} Cl^-(aq)$

During which process is there a **decrease** in the entropy of the system?

A. $\mathrm{Ag(s) + 2H^+(aq) + NO_3^-(aq) \rightarrow Ag^+(aq) + H_2O(l) + NO_2(g)}$

B. $\mathrm{Ba(OH)_2(s) \rightarrow BaO(s) + H_2O(g)}$

C. $\mathrm{PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)}$

D. $\mathrm{H_2O(s) \rightarrow H_2O(l)}$
