

Name \_\_\_\_\_

SL Score

HL Score

Key

Practice Exam: Paper 1

Topic 5: Energetics

/30

/56

SL

1. When  $100 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  HCl is mixed with  $100 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  NaOH, the temperature of the resulting solution is  $25.0^\circ\text{C}$ . What is the temperature change, in  $^\circ\text{C}$ , when  $50 \text{ cm}^3$  of these two solutions are mixed?

A. 2.5

B. 5.0

Skip for now!

2. Which statement about bonding is correct?

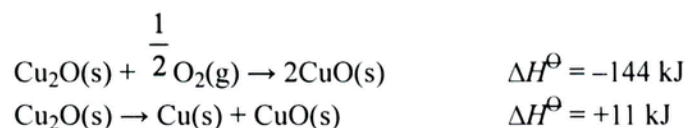
A. Bond breaking is endothermic and requires energy.

B. Bond breaking is endothermic and releases energy.

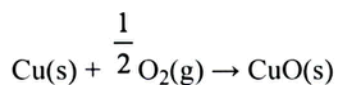
C. Bond making is exothermic and requires energy.

D. Bond making is endothermic and releases energy.

3. Consider the following reactions.



What is the value of  $\Delta H^\ominus$ , in kJ, for this reaction?



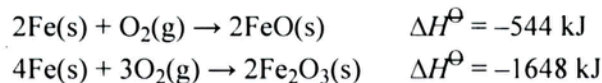
A.  $-144 + 11$

C.  $-144 - 11$

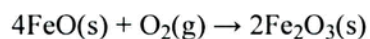
B.  $+144 - 11$

D.  $+144 + 11$

4. Consider the two reactions involving iron and oxygen.



What is the enthalpy change, in kJ, for the reaction below?



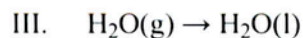
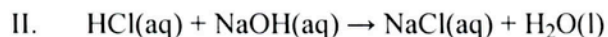
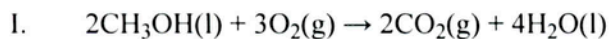
A.  $-1648 - 2(-544)$

C.  $-1648 - 544$

B.  $-544 - (-1648)$

D.  $-1648 - 2(544)$

5. Which processes have a negative enthalpy change?



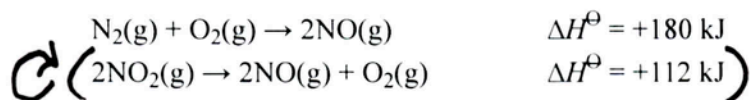
A. I and II only

B. I and III only

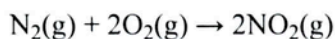
C. II and III only

D. I, II and III

6. Consider the following reactions.



What is the  $\Delta H^\ominus$  value, in kJ, for the following reaction?



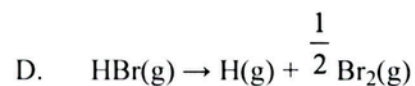
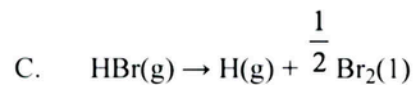
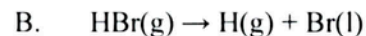
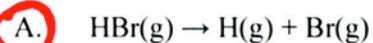
A.  $-1 \times (+180) + -1 \times (+112)$

B.  $-1 \times (+180) + 1 \times (+112)$

C.  $1 \times (+180) + -1 \times (+112)$

D.  $1 \times (+180) + 1 \times (+112)$

7. Which equation represents the bond enthalpy for the H–Br bond in hydrogen bromide?



8. Which types of reaction are always exothermic?

I. Neutralization

II. Decomposition

III. Combustion

A. I and II only

**B.** I and III only

C. II and III only

D. I, II and III

*Always exothermic*  
 $\text{Acid} + \text{Base} \rightarrow \text{Water} + \text{Salt}, \Delta H = \ominus$   
~~*Endothermic (usually)*  $AB \rightarrow A + B, \Delta H = \oplus$~~   
*Always exothermic*  
*(Combustion = burning!)*  
 $\Delta H = \ominus$

9. A pure aluminium block with a mass of 10 g is heated so that its temperature increases from  $20^\circ\text{C}$  to  $50^\circ\text{C}$ . The specific heat capacity of aluminium is  $8.99 \times 10^{-1} \text{ J g}^{-1} \text{ K}^{-1}$ . Which expression gives the heat energy change in kJ?

A.  $10 \times 8.99 \times 10^{-1} \times 303$

B.  $10 \times 8.99 \times 10^{-1} \times 30$

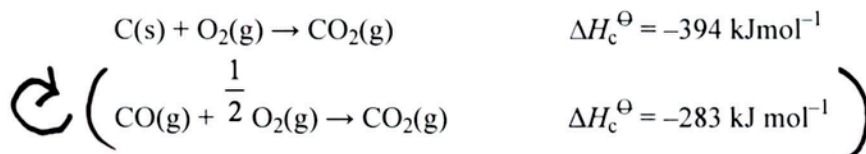
C.  $\frac{10 \times 8.99 \times 10^{-1} \times 303}{1000}$

**D.**  $\frac{10 \times 8.99 \times 10^{-1} \times 30}{1000}$

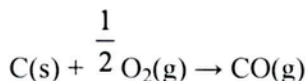
$q = mc\Delta T$   
 $= (10\text{g})(8.99 \times 10^{-1} \text{ J/g}\cdot^\circ\text{C})(30^\circ\text{C})$   
 $\times \frac{1\text{kJ}}{1000\text{J}}$

$\Delta T = 30^\circ\text{C}$

10. The standard enthalpy changes for the combustion of carbon and carbon monoxide are shown below.



What is the standard enthalpy change, in kJ, for the following reaction?



A. -677

**B.** -111

C. +111

D. +677

11. Which is correct about energy changes during bond breaking and bond formation?

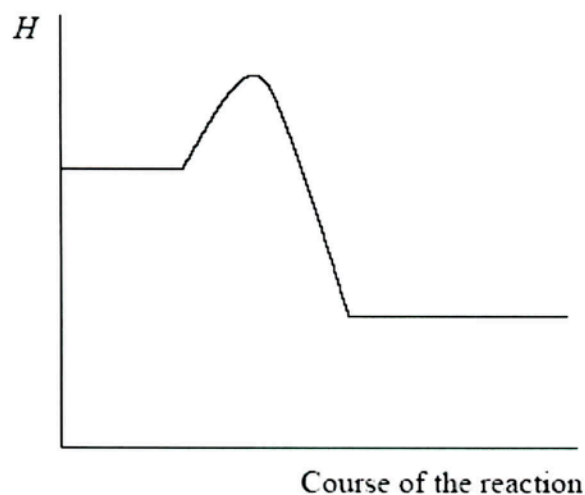
	<b>Bond breaking</b>	<b>Bond formation</b>
A.	exothermic and $\Delta H$ positive	endothermic and $\Delta H$ negative
B.	exothermic and $\Delta H$ negative	endothermic and $\Delta H$ positive
<b>C.</b>	endothermic and $\Delta H$ positive	exothermic and $\Delta H$ negative
D.	endothermic and $\Delta H$ negative	exothermic and $\Delta H$ positive

12. Which processes are exothermic?

- I. Ice melting
- II. Neutralization
- III. Combustion

- A. I and II only
- B. I and III only
- C.** II and III only
- D. I, II and III

13. Which statement is correct given the enthalpy level diagram below?

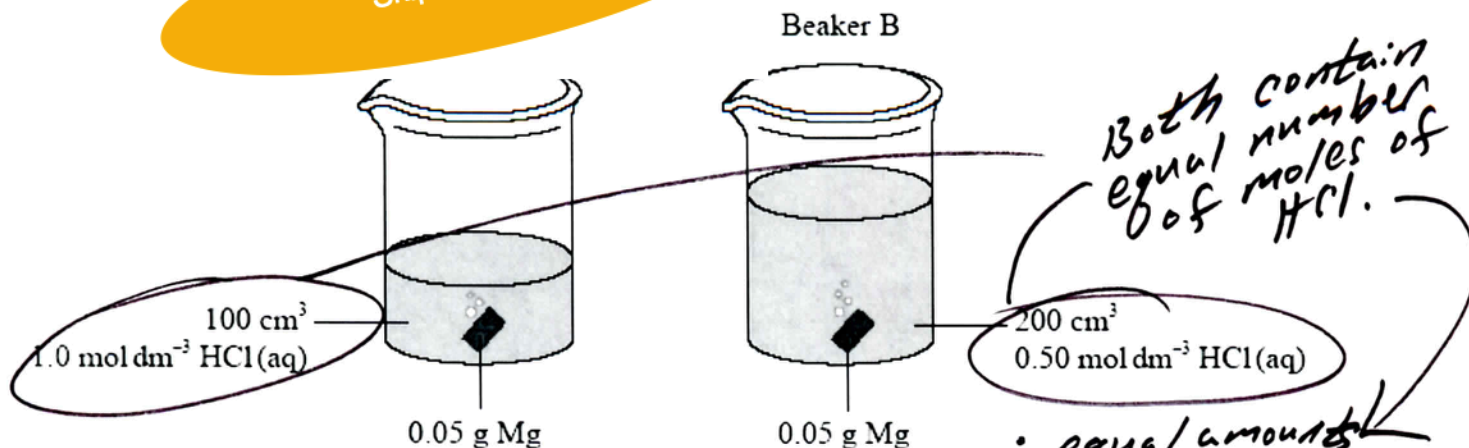


- A. The reaction is endothermic and the products are more thermodynamically stable than the reactants.
- B.** The reaction is exothermic and the products are more thermodynamically stable than the reactants.
- C. The reaction is endothermic and the reactants are more thermodynamically stable than the products.
- D. The reaction is exothermic and the reactants are more thermodynamically stable than the products.

14. Identical

Skip for now!

A and B, containing hydrochloric acid. Volumes and concentrations differ.



Which statement is correct?

- A. The maximum temperature in A will be higher than in B.
- B. The maximum temperature in A and B will be equal.
- C. It is not possible to predict whether A or B will have the higher maximum temperature.
- D. The temperature in A and B will increase at the same rate.

15. Which equation best represents the bond enthalpy of HCl?

- A.  $\text{HCl(g)} \rightarrow \text{H}^+(\text{g}) + \text{Cl}^-(\text{g})$
- B.  $\text{HCl(g)} \rightarrow \text{H(g)} + \text{Cl(g)}$
- C.  $\text{HCl(g)} \rightarrow \frac{1}{2} \text{H}_2(\text{g}) + \frac{1}{2} \text{Cl}_2(\text{g})$
- D.  $2\text{HCl(g)} \rightarrow \text{H}_2(\text{g}) + \text{Cl}_2(\text{g})$

16. When some solid barium hydroxide and solid ammonium thiosulfate were reacted together, the temperature of the surroundings was observed to decrease from 15 °C to -4 °C. What can be deduced from this observation?

- A. The reaction is exothermic and  $\Delta H$  is negative.
- B. The reaction is exothermic and  $\Delta H$  is positive.
- C. The reaction is endothermic and  $\Delta H$  is negative.
- D. The reaction is endothermic and  $\Delta H$  is positive.



17. Which process represents the C-Cl bond enthalpy in tetrachloromethane?

- A.  $\text{CCl}_4(\text{g}) \rightarrow \text{C}(\text{g}) + 4\text{Cl}(\text{g})$       C.  $\text{CCl}_4(\text{l}) \rightarrow \text{C}(\text{g}) + 4\text{Cl}(\text{g})$   
 B.  $\text{CCl}_4(\text{g}) \rightarrow \text{CCl}_3(\text{g}) + \text{Cl}(\text{g})$       D.  $\text{CCl}_4(\text{l}) \rightarrow \text{C}(\text{s}) + 2\text{Cl}_2(\text{g})$

18. Some water is heated using the heat produced by the combustion of magnesium metal. Which values are needed to calculate the enthalpy change of reaction?

- I. The mass of magnesium  
 II. The mass of the water  
 III. The change in temperature of the water

- A. I and II only      C. II and III only  
 B. I and III only      D. I, II and III

19. 1.0 g of sodium hydroxide, NaOH, was added to 99.0 g of water. The temperature of the solution increased from 18.0 °C to 20.5 °C. The specific heat capacity of the solution is  $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ .

Which expression gives the heat evolved in  $\text{kJ mol}^{-1}$ ?

A.  $\frac{2.5 \times 100.0 \times 4.18 \times 1000}{40.0}$

B.  $\frac{2.5 \times 100.0 \times 4.18}{1000 \times 40.0}$

C.  $\frac{2.5 \times 100.0 \times 4.18 \times 40.0}{1000}$

D.  $\frac{2.5 \times 1.0 \times 4.18 \times 40.0}{1000}$

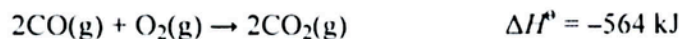
$$\Delta H = \frac{q}{\text{mol}} = \frac{cm\Delta T}{\text{mol}}$$

$$= \frac{(4.18 \text{ J/g}^\circ\text{C})(100.0)(2.5)}{(1.0 \text{ g} \times \frac{1 \text{ mol}}{40.0 \text{ g}})}$$

$$= \frac{(\frac{4.18 \text{ kJ}}{1000 \text{ J}})(100.0)(2.5)}{(\frac{1}{40.0})}$$

$$= \frac{(4.18)(100.0)(2.5)(40.0)}{1000}$$
 }  $\Delta T = 20.5 - 18.0 = 2.5$   
 mass of solution = 1.0 + 99.0 = 100.0

20. What is the energy, in kJ, released when 1.00 mol of carbon monoxide is burned according to the following equation?



A. 141

B. 282

C. 564

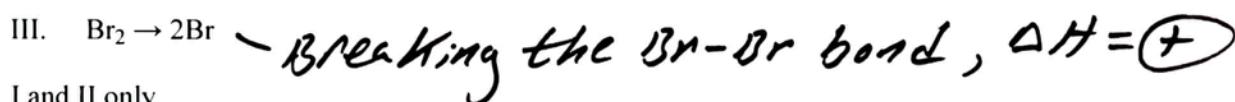
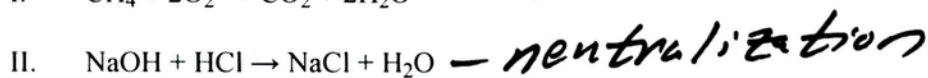
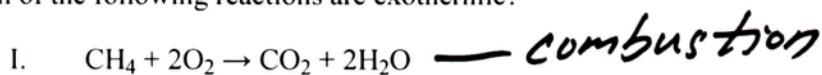
D. 1128

21. The specific heat of iron is  $0.450 \text{ J g}^{-1} \text{ K}^{-1}$ . What is the energy, in J, needed to increase the temperature of 50.0 g of iron by 20.0 K?

$$q = cm\Delta T$$

- A. 9.00
- B. 22.5
- C. 45.0
- D. 450

22. Which of the following reactions are exothermic?



- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

A Kinetics question

hydrochloric acid. Which factors will affect the reaction rate?

ctant particles

with  $E \geq E_a$

III. The number of reactant particles that collide with the appropriate geometry

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Skip for now!

- C. Solid zinc chloride
- D. Molten zinc chloride

25. Which is true for a chemical reaction in which the products have a higher enthalpy than the reactants?

	Reaction	$\Delta H$
A.	endothermic	positive
B.	endothermic	negative
C.	exothermic	positive
D.	exothermic	negative

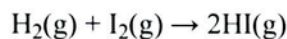
$$\therefore \Delta H = \ominus$$

26. In a reaction that occurs in 50 g of aqueous solution, the temperature of the reaction mixture increases by 20 °C. If 0.10 mol of the limiting reagent is consumed, what is the enthalpy change (in kJ mol<sup>-1</sup>) for the reaction? Assume the specific heat capacity of the solution = 4.2 kJ kg<sup>-1</sup> K<sup>-1</sup>.

$$\Delta H = \frac{-q}{\text{mol}} = \frac{-cm\Delta T}{\text{mol}}$$

- A.  $-0.10 \times 50 \times 4.2 \times 20$   
 B.  $-0.10 \times 0.050 \times 4.2 \times 20$   
 C.  $\frac{-50 \times 4.2 \times 20}{0.10}$   
 D.  $\frac{-0.050 \times 4.2 \times 20}{0.10}$

27. Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.



Bond	Bond energy / kJ mol <sup>-1</sup>
H-H	440
I-I	150
H-I	300

- A. +290      C. -10  
 B. +10      D. -290

28. How much energy, in joules, is required to increase the temperature of 2.0 g of aluminium from 25 to 30 °C? (Specific heat of Al = 0.90 J g<sup>-1</sup> K<sup>-1</sup>).

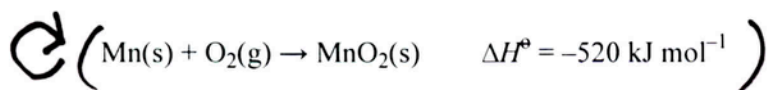
- A. 0.36  
 B. 4.5  
 C. 9.0  
 D. 54



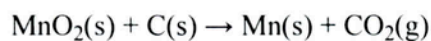
29. Which combination is correct for a chemical reaction that absorbs heat from the surroundings?

	Type of reaction	$\Delta H$ at constant pressure
A.	Exothermic	Positive
B.	Exothermic	Negative
<b>C.</b>	Endothermic	Positive
D.	Endothermic	Negative

30. Using the equations below:



What is  $\Delta H$ , in kJ, for the following reaction?

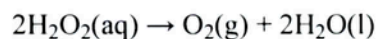


A. 914                      C. -126

**B.** 126                      D. -914

## HL

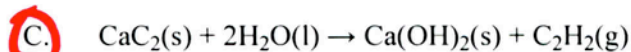
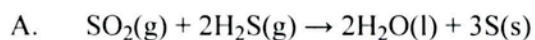
1. When hydrogen peroxide decomposes, the temperature of the reaction mixture increases.



What are the signs of  $\Delta H$ ,  $\Delta S$  and  $\Delta G$  for this reaction?

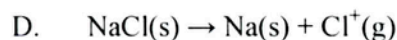
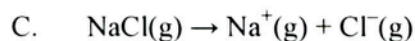
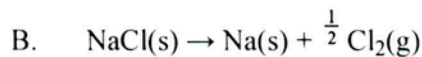
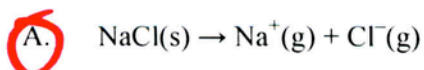
	$\Delta H$	$\Delta S$	$\Delta G$
A.	-	-	-
<b>B.</b>	-	+	-
C.	+	+	-
D.	-	+	+

2. Which reaction has the greatest increase in entropy?

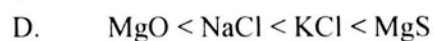
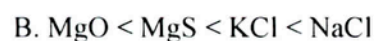
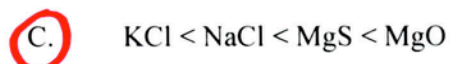


3. Which equation corresponds to the lattice enthalpy for silver iodide, AgI?
- A.  $\text{AgI(s)} \rightarrow \text{Ag(s)} + \text{I(g)}$
- B.  $\text{AgI(s)} \rightarrow \text{Ag(s)} + \frac{1}{2} \text{I}_2(\text{g})$
- C.  $\text{AgI(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq})$
- D.**  $\text{AgI(s)} \rightarrow \text{Ag}^+(\text{g}) + \text{I}^-(\text{g})$
4. Which ionic compound has the greatest lattice enthalpy?
- A.** MgO                      C. NaF
- B. CaO                      D. KF
5. 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
6.  $\Delta G^\ominus$  calculations predict that a reaction is always spontaneous for which of the following combinations of  $\Delta H^\ominus$  and  $\Delta S^\ominus$ ?
- A.  $+\Delta H^\ominus$  and  $+\Delta S^\ominus$                       C.  $-\Delta H^\ominus$  and  $-\Delta S^\ominus$
- B.  $+\Delta H^\ominus$  and  $-\Delta S^\ominus$                       **D.**  $-\Delta H^\ominus$  and  $+\Delta S^\ominus$
7. Which reaction has an enthalpy change equal to a standard enthalpy change of formation,  $\Delta H_f^\ominus$ ?  
All reactions occur at 298 K and  $1.01 \times 10^5$  Pa.
- A.  $\text{C}_4\text{H}_8(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{C}_4\text{H}_9\text{OH}(\text{l})$
- B.  $4\text{CO}_2(\text{g}) + 5\text{H}_2\text{O}(\text{g}) \rightarrow \text{C}_4\text{H}_9\text{OH}(\text{l}) + \frac{13}{2} \text{O}_2(\text{g})$
- C.**  $4\text{C}(\text{s}) + 5\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{C}_4\text{H}_9\text{OH}(\text{l})$
- D.  $8\text{C}(\text{s}) + 10\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{C}_4\text{H}_9\text{OH}(\text{l})$

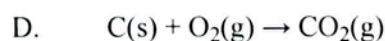
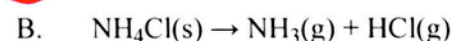
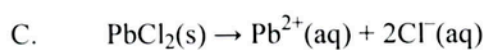
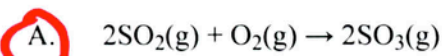
8. Which process has an enthalpy change that represents the lattice enthalpy of sodium chloride?



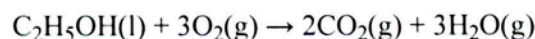
9. Which is the correct order of increasing magnitude of lattice enthalpy (lowest first)?



10. Which reaction has the most negative change in entropy?



11. What is the standard free energy change,  $\Delta G^\ominus$ , in kJ, for the following reaction?



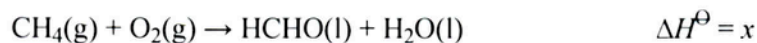
Compound	$\Delta G_f^\ominus / \text{kJ mol}^{-1}$
$\text{C}_2\text{H}_5\text{OH(l)}$	-175
$\text{CO}_2(\text{g})$	-394
$\text{H}_2\text{O(g)}$	-229
$\text{O}_2(\text{g})$	0



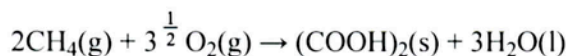
12. Which combination of ionic radius and ionic charge would result in the highest lattice enthalpy for an ionic compound?

	Ionic radius	Ionic charge
<input checked="" type="radio"/> A.	small	high
B.	large	high
C.	small	low
D.	large	low

13. Consider the equations below.



What is the enthalpy change of the reaction below?



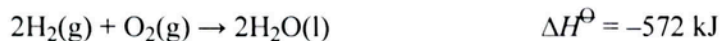
A.  $x + y + z$

C.  $2x + 2y + z$

B.  $2x + y + z$

D.  $2x + 2y + 2z$

14. Given the enthalpy change for the reaction below:



which statement is correct?

A. The standard enthalpy change of combustion of  $\text{H}_2(\text{g})$  is  $-286 \text{ kJ mol}^{-1}$ .

B. The standard enthalpy change of combustion of  $\text{H}_2(\text{g})$  is  $+286 \text{ kJ mol}^{-1}$ .

C. The standard enthalpy change of formation of  $\text{H}_2\text{O}(\text{l})$  is  $-572 \text{ kJ mol}^{-1}$ .

D. The standard enthalpy change of formation of  $\text{H}_2\text{O}(\text{l})$  is  $+572 \text{ kJ mol}^{-1}$ .

15. Which is a correct definition of lattice enthalpy?

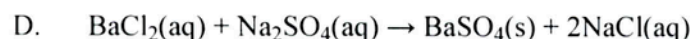
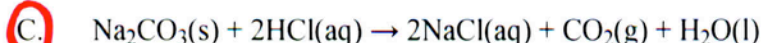
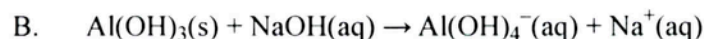
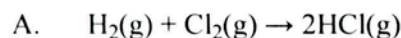
A. It is the enthalpy change that occurs when an electron is removed from 1 mol of gaseous atoms.

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.

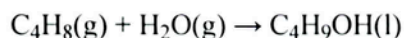
16. Which reaction has the largest increase in entropy?



17. Which reaction has the greatest increase in entropy?

- A.  $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$   
B.  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$   
C.  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$   
D.  $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$

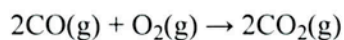
18. The reaction between but-1-ene and water vapour produces butan-1-ol.



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

- A.  $-271$                       C.  $-107$   
B.  $+271$                         D.  $+107$

19. What is the standard entropy change,  $\Delta S^\ominus$ , for the following reaction?



	<b>CO(g)</b>	<b>O<sub>2</sub>(g)</b>	<b>CO<sub>2</sub>(g)</b>
$S^\ominus/\text{J K}^{-1} \text{ mol}^{-1}$	198	205	214

- A.  $-189$                       C.  $+173$   
 B.  $-173$                       D.  $+189$

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

- A.  $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$  **and**  $\text{Li}(\text{s}) \rightarrow \text{Li}(\text{g})$   
B.  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$  **and**  $\text{Li}(\text{g}) \rightarrow \text{Li}^+(\text{g}) + \text{e}^-$   
C.  $\text{Li}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{LiCl}(\text{s})$   
D.  $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}(\text{g})$  **and**  $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$

21. Which ionic compound has the most endothermic lattice enthalpy?

- A. NaCl                       C. NaF  
B. KCl                        D. KF



22. Which change leads to an increase in entropy?

- A.  $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$       C.  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$   
B.  $\text{SF}_6(\text{g}) \rightarrow \text{SF}_6(\text{l})$       D.  $\text{NaCl}(\text{s}) \rightarrow \text{NaCl}(\text{aq})$

23. Which reaction has the most negative  $\Delta H^\circ$  value?

- A.  $\text{LiF}(\text{s}) \rightarrow \text{Li}^+(\text{g}) + \text{F}^-(\text{g})$   
B.  $\text{Li}^+(\text{g}) + \text{F}^-(\text{g}) \rightarrow \text{LiF}(\text{s})$   
C.  $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{g}) + \text{Cl}^-(\text{g})$   
D.  $\text{Na}^+(\text{g}) + \text{Cl}^-(\text{g}) \rightarrow \text{NaCl}(\text{s})$

24. Which equation represents the electron affinity of calcium?

- A.  $\text{Ca}(\text{g}) \rightarrow \text{Ca}^+(\text{g}) + \text{e}^-$   
B.  $\text{Ca}(\text{g}) \rightarrow \text{Ca}^-(\text{g}) + \text{e}^-$   
C.  $\text{Ca}(\text{g}) + \text{e}^- \rightarrow \text{Ca}^-(\text{g})$   
D.  $\text{Ca}^+(\text{g}) + \text{e}^- \rightarrow \text{Ca}(\text{g})$

25. Which reaction causes a decrease in the entropy of the system?

- A.  $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$   
B.  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$   
C.  $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g})$   
D.  $2\text{SO}_3(\text{g}) \rightarrow 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$

26. What are the signs of  $\Delta H^\circ$  and  $\Delta S^\circ$  for a reaction that is non-spontaneous at low temperature but spontaneous at high temperature?

	$\Delta H^\circ$	$\Delta S^\circ$
A.	-	-
B.	+	-
C.	-	+
D.	+	+