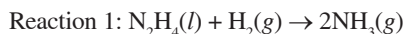


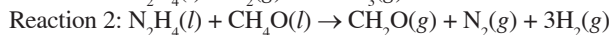
## CHAPTER 7 QUESTIONS

### Multiple-Choice Questions

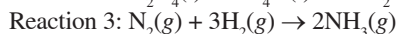
Use the following information to answer questions 1-5.



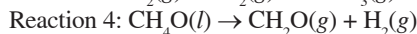
$$\Delta H = ?$$



$$\Delta H = -37 \text{ kJ/mol}_{\text{rxn}}$$

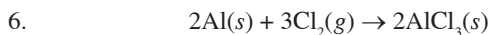


$$\Delta H = -46 \text{ kJ/mol}_{\text{rxn}}$$



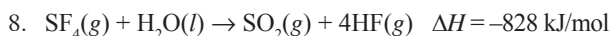
$$\Delta H = -65 \text{ kJ/mol}_{\text{rxn}}$$

- What is the enthalpy change for reaction 1?
  - 148 kJ/mol<sub>rxn</sub>
  - 56 kJ/mol<sub>rxn</sub>
  - 18 kJ/mol<sub>rxn</sub>
  - +148 kJ/mol<sub>rxn</sub>
- If reaction 2 were repeated at a higher temperature, how would the reaction's value for  $\Delta G$  be affected?
  - It would become more negative because entropy is a driving force behind this reaction.
  - It would become more positive because the reactant molecules would collide more often.
  - It would become more negative because the gases will be at a higher pressure.
  - It will stay the same; temperature does not affect the value for  $\Delta G$ .
- Under what conditions would reaction 3 be thermodynamically favored?
  - It is always favored.
  - It is never favored.
  - It is only favored at low temperatures.
  - It is only favored at high temperatures.
- If 64 g of  $\text{CH}_4\text{O}$  were to decompose via reaction 4, approximately how much energy would be released or absorbed?
  - 65 kJ of energy will be absorbed.
  - 65 kJ of energy will be released.
  - 130 kJ of energy will be absorbed.
  - 130 kJ of energy will be released.
- A 2.0 L flask holds 0.40 g of helium gas. If the helium is evacuated into a larger container while the temperature is held constant, what will the effect on the entropy of the helium be?
  - It will remain constant because the number of helium molecules does not change.
  - It will decrease because the gas will be more ordered in the larger flask.
  - It will decrease because the molecules will collide with the sides of the larger flask less often than they did in the smaller flask.
  - It will increase because the gas molecules will be more dispersed in the larger flask.



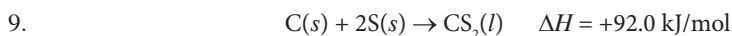
The reaction above is not thermodynamically favored under standard conditions, but it becomes thermodynamically favored as the temperature decreases toward absolute zero. Which of the following is true at standard conditions?

- (A)  $\Delta S$  and  $\Delta H$  are both negative.  
 (B)  $\Delta S$  and  $\Delta H$  are both positive.  
 (C)  $\Delta S$  is negative, and  $\Delta H$  is positive.  
 (D)  $\Delta S$  is positive, and  $\Delta H$  is negative.
7. 1.50 g of  $\text{NaNO}_3$  is dissolved into 25.0 mL of water, causing the temperature to increase by  $2.2^\circ\text{C}$ . The density of the final solution is found to be 1.02 g/mL. Which of the following expressions will correctly calculate the heat gained by the water as the  $\text{NaNO}_3$  dissolves? Assume the volume of the solution remains unchanged.
- (A)  $(25.0)(4.18)(2.2)$   
 (B)  $\frac{(26.5)(4.18)(2.2)}{1.02}$   
 (C)  $\frac{(1.02)(4.18)(2.2)}{1.50}$   
 (D)  $(25.0)(1.02)(4.18)(2.2)$

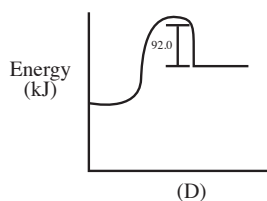
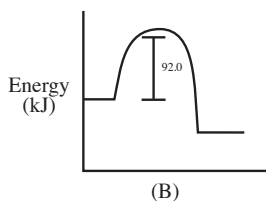
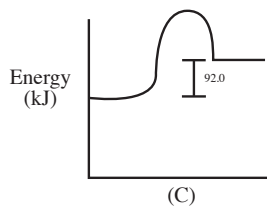
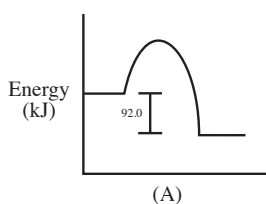


Which of the following statements accurately describes the above reaction?

- (A) The entropy of the reactants exceeds that of the products.  
 (B)  $\text{H}_2\text{O}(l)$  will always be the limiting reagent.  
 (C) This reaction is never thermodynamically favored.  
 (D) The temperature of the surroundings will increase as this reaction progresses.

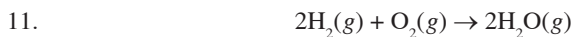


Which of the following energy level diagrams gives an accurate representation of the above reaction?



10. A student studies two solutions. Solution A has a volume of 100 mL and is at a temperature of 25.0°C. Solution B has a volume of 1000 mL and is at a temperature of 22.0°C. Which of the following statements must be true regarding both solutions?

(A) Solution A has more heat than solution B.  
 (B) The specific heat capacity of solution A is greater than that of solution B.  
 (C) If the solutions were to be mixed, heat would transfer from B to A.  
 (D) Solution B has more thermal energy than solution A.



Based on the information given in the table below, what is  $\Delta H^\circ$  for the above reaction?

Bond	Average bond energy (kJ/mol)
H–H	500
O=O	500
O–H	500

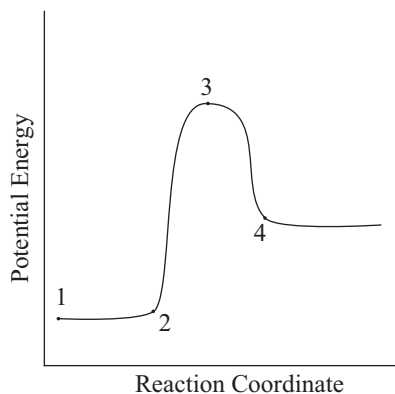
(A) –2,000 kJ  
 (B) –500 kJ  
 (C) +1,000 kJ  
 (D) +2,000 kJ



Which of the following is true for the above reaction at 298 K?

(A) The value for  $\Delta S$  is positive.  
 (B) The value for  $\Delta G$  is zero.  
 (C) The value for  $\Delta H$  is positive.  
 (D) The reaction is favored.

Use the following diagram to answer questions 13-15.



13. Which point on the graph shown above corresponds to activated complex or transition state?

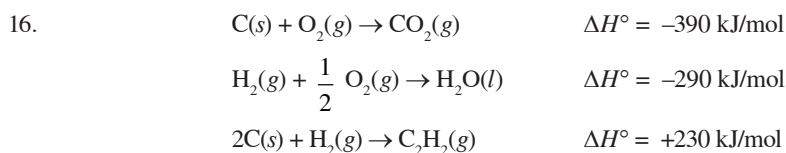
(A) 1  
 (B) 2  
 (C) 3  
 (D) 4

14. The distance between which two points is equal to the enthalpy change for this reaction?

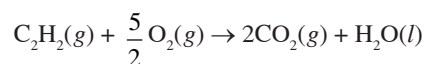
- (A) Points 1 and 2
- (B) Points 1 and 3
- (C) Points 1 and 4
- (D) Points 2 and 3

15. What would happen to this graph if a catalyst were to be added?

- (A) Point 3 would be lower.
- (B) The distance between points 2 and 4 would be decreased.
- (C) The slope of the line between points 2 and 3 would increase.
- (D) Point 4 would be higher.



Based on the information given above, what is  $\Delta H^\circ$  for the following reaction?

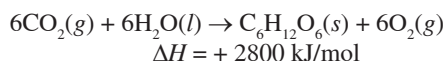


- (A)  $-1,300 \text{ kJ}$
- (B)  $-1,070 \text{ kJ}$
- (C)  $-840 \text{ kJ}$
- (D)  $-780 \text{ kJ}$

17. In which of the following reactions is entropy increasing?

- (A)  $2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)$
- (B)  $\text{CO}(g) + \text{H}_2\text{O}(g) \rightarrow \text{H}_2(g) + \text{CO}_2(g)$
- (C)  $\text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2\text{HCl}(g)$
- (D)  $2\text{NO}_2(g) \rightarrow 2\text{NO}(g) + \text{O}_2(g)$

18. Consider the following reaction showing photosynthesis:



Which of the following is true regarding the thermal energy in this system?

- (A) It is transferred from the surroundings to the reaction.
- (B) It is transferred from the reaction to the surroundings.
- (C) It is transferred from the reactants to the products.
- (D) It is transferred from the products to the reactants.



Gaseous hydrogen and fluorine combine in the reaction above to form hydrogen fluoride with an enthalpy change of  $-540 \text{ kJ}$ . What is the value of the heat of formation of  $\text{HF}(g)$ ?

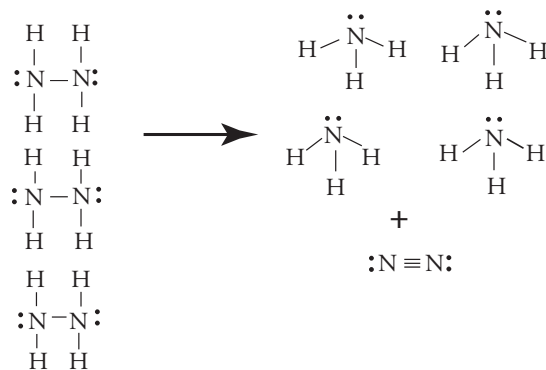
- (A)  $-1,080 \text{ kJ/mol}$
- (B)  $-270 \text{ kJ/mol}$
- (C)  $270 \text{ kJ/mol}$
- (D)  $540 \text{ kJ/mol}$

Use the following information to answer questions 20-23.

When calcium chloride ( $\text{CaCl}_2$ ) dissolves in water, the temperature of the water increases dramatically.

20. Which of the following must be true regarding the enthalpy of solution?
- The lattice energy in  $\text{CaCl}_2$  exceeds the bond energy within the water molecules.
  - The hydration energy between the water molecules and the solute ions exceeds the lattice energy within  $\text{CaCl}_2$ .
  - The strength of the intermolecular forces between the solute ions and the dipoles on the water molecules must exceed the hydration energy.
  - The hydration energy must exceed the strength of the intermolecular forces between the water molecules.
21. During this reaction, heat transfers from
- the reactants to the products
  - the reactants to the system
  - the system to the surroundings
  - the products to the surroundings
22. Which is the primary driving factor behind this reaction?
- Entropy
  - Enthalpy
  - Both enthalpy and entropy
  - Neither enthalpy nor entropy
23. Compared to  $\text{CaCl}_2$ , what must be true regarding the hydration energy of  $\text{CaF}_2$ ?
- It would be greater because fluoride is smaller than chloride.
  - It would be the same because the charges of fluoride and chloride are identical.
  - It would be the same because hydration energy is only dependent on the IMFs present in water.
  - It would be smaller because the molar mass of  $\text{CaF}_2$  is smaller than that of  $\text{CaCl}_2$ .

24. The reaction shown in the diagram below is accompanied by a large increase in temperature. If all molecules shown are in their gaseous state, which statement accurately describes the reaction?



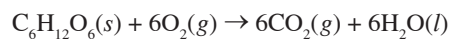
- It is an exothermic reaction in which entropy increases.
- It is an exothermic reaction in which entropy decreases.
- It is an endothermic reaction in which entropy increases.
- It is an endothermic reaction in which entropy decreases.

## Free-Response Questions

1.

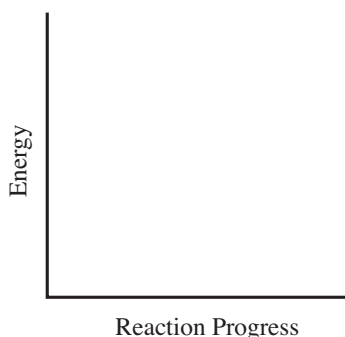
Substance	Absolute Entropy, $S$ (J/mol•K)	Molar Mass (g/mol)
$C_6H_{12}O_6(s)$	212.13	180
$O_2(g)$	205	32
$CO_2(g)$	213.6	44
$H_2O(l)$	69.9	18

Energy is released when glucose is oxidized in the following reaction, which is a metabolism reaction that takes place in the body.



The standard enthalpy change,  $\Delta H^\circ$ , for the reaction is  $-2,801 \text{ kJ/mol}_{\text{rxn}}$  at 298 K.

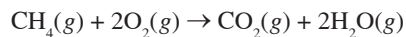
- Calculate the standard entropy change,  $\Delta S^\circ$ , for the oxidation of glucose.
- Calculate the standard free energy change,  $\Delta G^\circ$ , for the reaction at 298 K.
- Using the axis below, draw an energy profile for the reaction and indicate the magnitude of  $\Delta H$ .



- How much energy is given off by the oxidation of 1.00 gram of glucose?

2.

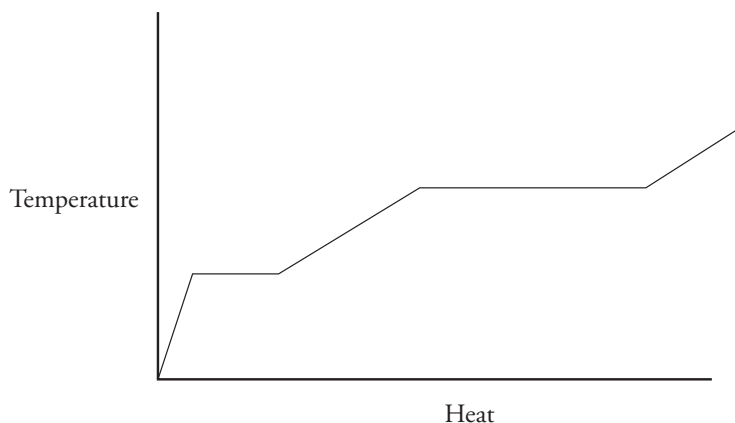
Bond	Average Bond Dissociation Energy (kJ/mol)
C–H	415
O=O	495
C=O	799
O–H	463



The standard free energy change,  $\Delta G^\circ$ , for the reaction above is  $-801 \text{ kJ/mol}_{\text{rxn}}$  at 298 K.

- Use the table of bond dissociation energies to find  $\Delta H^\circ$  for the reaction above.
- How many grams of methane must react with excess oxygen in order to release 1500 kJ of heat?
- What is the value of  $\Delta S^\circ$  for the reaction at 298 K?
- Give an explanation for the size of the entropy change found in (c).

3.



The diagram above shows how the temperature of a certain covalent substance changes as heat is added to it.

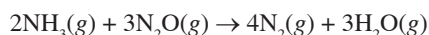
- Which is greater for the substance: the heat of fusion or the heat of vaporization? How do you know?
- If additional heat is added to the substance, the line would continue at its current slope and never become horizontal again. Why is this?
- Reading the graph above, a student theorizes that the specific heat capacity of the substance is greatest in the solid phase. Do you agree? Why or why not?
- What would the signs be for the enthalpy and entropy changes as heat continues to be added? Justify your answer.



For the boiling of methanol,  $\text{CH}_3\text{OH}$ ,  $\Delta H = +37.6 \text{ kJ/mol}$  and  $\Delta S = +111 \text{ J/mol} \cdot \text{K}$ .

- (i) Why is the  $\Delta H$  value positive for this process?  
(ii) Why is the  $\Delta S$  value positive for this process?
- What is the boiling point of methanol in degrees Celsius?
- How much heat is required to boil 50.0 mL of ethanol if the density of ethanol is 0.789 g/mL?
- What will happen to the temperature of the methanol as it boils? Explain.
- Would methanol be soluble with water? Why or why not?
- Would you expect the boiling point of ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$ , to be less than, greater than, or the same as methanol? Justify your answer.

5. Ammonia gas reacts with dinitrogen monoxide via the following reaction:



The absolute entropy values for the varying substances are listed in the table below.

Substance	$S^\circ$ (J/mol·K)
$\text{NH}_3(g)$	193
$\text{N}_2\text{O}(g)$	220
$\text{N}_2(g)$	192
$\text{H}_2\text{O}(g)$	189

- Calculate the entropy value for the overall reaction.

Several bond enthalpies are listed in the table below.

Bond	Enthalpy (kJ/mol)	Bond	Enthalpy (kJ/mol)
N–H	388	N=N	409
N–O	210	N≡N	941
N=O	630	O–H	463

- Calculate the enthalpy value for the overall reaction.
- Is this reaction thermodynamically favored at 25°C? Justify your answer.
- If 25.00 g of  $\text{NH}_3$  reacts with 25.00 g of  $\text{N}_2\text{O}$ :
  - Will energy be released or absorbed?
  - What is the magnitude of the energy change?
- On the reaction coordinates below, draw a line showing the progression of this reaction. Label both  $\Delta H$  and  $E_a$  on the graph.

Potential  
Energy  
(kJ/mol)

Reaction Progress



6. A student designs an experiment to determine the specific heat of aluminum. The student heats a piece of aluminum with a mass of 5.86 g to various temperatures, and then drops it into a calorimeter containing 25.0 mL of water. The following data is gathered during one of the trials:

Initial Temperature of Al ( C )	Initial Temperature of H <sub>2</sub> O ( C )	Final Temperature of Al + H <sub>2</sub> O ( C )
109.1	23.2	26.8

- Given that the specific heat of water is 4.18 J/g·°C and assuming its density is exactly 1.00 g/mL, calculate the heat gained by the water.
- Calculate the specific heat of aluminum from the experimental data given.
- Calculate the enthalpy change for the cooling of aluminum in water in kJ/mol.
- If the accepted specific heat of aluminum is 0.900 J/g·°C, calculate the percent error.
- Suggest two potential sources of error that would lead the student's experimental value to be different from the actual value. Be specific in your reasoning and make sure any identified error can be quantitatively tied to the student's results.