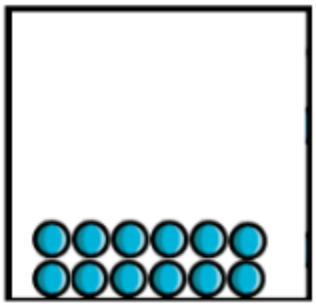
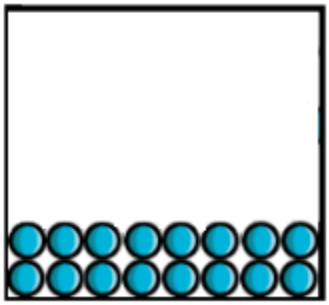
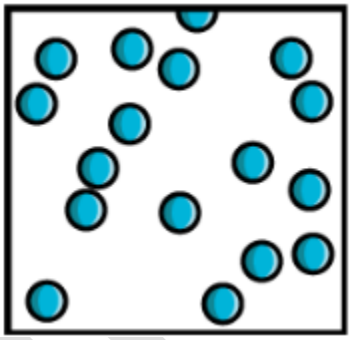
ENTROPY WORKSHEET

Entropy is the degree of randomness in a substance. The symbol for change in entropy is ΔS. Solids are very ordered and have low entropy. Liquids and aqueous ions have more entropy because they move about more freely, and gases have an even larger amount of entropy. According to the Second Law of Thermodynamics, nature is always proceeding to a state of higher entropy.







Determine whether the following reactions show an increase or decrease in entropy (positive ΔS or negative ΔS).

1.) $2\ KClO_3\ (s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$

2.) $H_2O\ (\ell) \rightarrow H_2O\ (s)$

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

4.) $NaCl\ (s) \rightarrow Na^{+1}\ (aq) + Cl^{-1}\ (aq)$

5.) $KCl\ (s) \rightarrow KCl\ (\ell)$

6.) $CO_2\ (s) \rightarrow CO_2\ (g)$

7.) $H^{+1}\ (aq) + C_2H_3O_2^{-1}\ (aq) \rightarrow HC_2H_3O_2\ (\ell)$

8.) $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$

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

10.) $Ag^{+1}\ (aq) + Cl^{-1}\ (aq) \rightarrow AgCl\ (s)$

11.) $2\ N_2O_5\ (g) \rightarrow 4\ NO_2\ (g) + O_2\ (g)$

12.) $2\ Al\ (s) + 3\ I_2\ (s) \rightarrow 2\ AlI_3\ (s)$

13.) $H^{+1}\ (aq) + OH^{-1}\ (aq) \rightarrow H_2O\ (\ell)$

14.) $2\ NO\ (g) \rightarrow N_2\ (g) + O_2\ (g)$

15.) $H_2O\ (g) \rightarrow H_2O\ (\ell)$

GIBBS FREE ENERGY WORKSHEET

The equation for Gibbs Free Energy is: $\Delta G = \Delta H - T\Delta S$

For a reaction to be spontaneous, the sign for ΔG has to be negative. ΔH represents the heat of reaction. ΔS is the change in entropy. T is temperature in Kelvins.

A negative value for ΔH means that the reaction is exothermic. That means that heat is released.
A positive value for ΔH means that the reaction is endothermic. That means that heat is absorbed.
A negative value for ΔS means that the products are more ordered than the reactants.
A positive value for ΔS means that the products are less ordered than the reactants.

Part 1 - Complete the following table for the sign of ΔG: +, -, or undetermined. When undetermined, the temperature determines the sign of ΔG.

ΔH	ΔS	ΔG
-	+	
+	-	
-	-	
+	+	

Part 2 - Consider the following reactions. Determine the signs for ΔH and ΔS. Then decide whether the reaction is sometimes, always, or never spontaneous.

3. $NaOH\ (s) \rightarrow Na^{+1}\ (aq) + OH^{-1}\ (aq) + energy$
   ΔH = ____ ΔS = ____ ΔG = ____ _____ spontaneous

4. $energy + 2\ H_2\ (g) + O_2\ (g) \rightarrow H_2O\ (\ell)$
   ΔH = ____ ΔS = ____ ΔG = ____ _____ spontaneous

5. $energy + H_2O\ (s) \rightarrow H_2O\ (\ell)$
   ΔH = ____ ΔS = ____ ΔG = ____ _____ spontaneous

Part 4 - Solve the following problems.

6. What is the value of ΔG if ΔH = -32.0 kJ, ΔS = +25.0 kJ/K, and T = 20 °C?
7. Is the reaction described in problem 6 spontaneous?

8. What is the value of ΔG if ΔH = +12.0 kJ, ΔS = -5.00 kJ/K, and T = 290. K?
9. Is the reaction described in problem 8 spontaneous?

ENERGY & CHEMICAL REACTIONS WORKSHEET

1. In your best judgment, which of the following in the pair has the highest entropy?
   A. (A) messy room (B) neat room
   B. (A) ice (B) steam
   C. (A) solid salt crystals (B) salt dissolved in water
   D. (A) iron filings & sulfur powder (B) solid iron sulfide

2. Indicate whether the following describes endothermic or exothermic reactions.
   (A) reactants have higher enthalpy than products (B) produces energy as it proceeds
   (C) products have very high enthalpy (D) ΔH is always positive
   (E) needs a continuous energy supply as they proceed

3. What is the "direction" or trend most chemical reactions move toward in terms of energy and disorder?

4. What do the following symbols represent:
   (A) ΔH (B) ΔS (C) ΔG

5. What is the general formula for determining the free energy of a chemical reaction?

6. What does a + ΔG value indicate about a reaction?

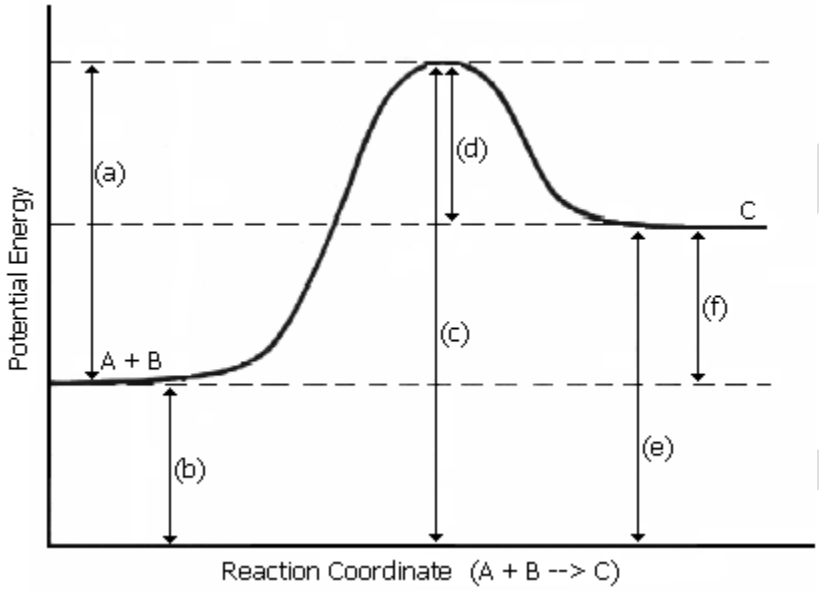
7. What does a - ΔG value indicate about a reaction?

8. Match the following:

___ + ΔH	(A) spontaneous reaction
___ - ΔH	(B) endothermic reaction
___ - ΔG	(C) exothermic reaction
___ + ΔG	(D) nonspontaneous reaction

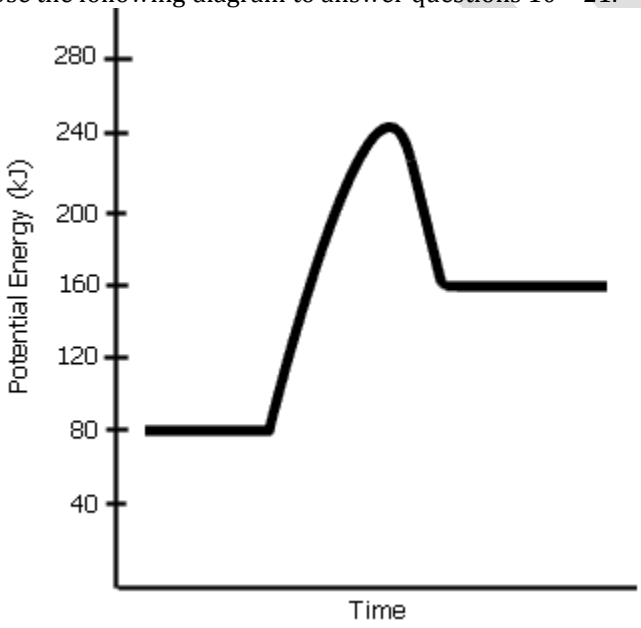
REACTION PATHWAY DIAGRAM WORKSHEET

Use the following reaction pathway diagram to answer questions 1 – 9.



1. Which of the letters a–f in the diagram represents the potential energy of the products?
2. Which letter indicates the potential energy of the activated complex?
3. Which letter indicates the potential energy of the reactants?
4. Which letter indicates the activation energy?
5. Which letter indicates the heat of reaction?
6. Is the reaction exothermic or endothermic?
7. Which letter indicates the activation energy of the reverse reaction?
8. Which letter indicates the heat of reaction of the reverse reaction?
9. Is the reverse reaction exothermic or endothermic?

Use the following diagram to answer questions 10 – 21.



10. The heat content of the reactants of the forward reaction is about _____ kilojoules.

11. The heat content of the products of the forward reaction is about _____kilojoules.

12. The heat content of the activated complex of the forward reaction is about _____ kilojoules.

13. The activation energy of the forward reaction is about _____ kilojoules.

14. The heat of reaction (ΔH) of the forward reaction is about _____ kilojoules.

15. The forward reaction is (endothermic/exothermic).

16. The heat content of the reactants of the reverse reaction is about _____ kilojoules.

17. The heat content of the products of the reverse reaction is about _____ kilojoules.

18. The heat content of the activated complex of the reverse reaction is about _____kilojoules.

19. The activation energy of the reverse reaction is about _____ kilojoules.

20. The heat of reaction (ΔH) of the reverse reaction is about _____ kilojoules.

21. The reverse reaction is (endothermic/exothermic).

Answer the following questions.

22. Chemical reactions occur when reactants collide. For what reasons may a collision fail to produce a chemical reaction?

23. If every collision between reactants lead to a reaction, what determines the rate at which the reaction occurs?

24. What is the activation energy of a reaction, and how is this energy related to the activated complex of the reaction?

25. What happens when a catalyst is used in a reaction?

26. Name 4 things that will speed up or slow down a chemical reaction.

27. Draw an energy diagram for a reaction. (Label the axes.)

Potential energy of reactants = 350 kJ
Activation energy = 100 kJ
Potential energy of products = 250 kJ

28. Is the reaction in #27 exothermic or endothermic? Explain.

29. How could you lower the activation energy for the reaction in #27?