

Chemistry 12
Worksheet 2-1 - Equilibrium, Enthalpy
and Entropy

1. What do people mean when they say that a reaction is *reversible*? _____

2. Give *four* things which are true about a system *at equilibrium*:
 1. _____
 2. _____
 3. _____
 4. _____
3. What is meant by *macroscopic properties*? _____

4. Give some examples of macroscopic properties: _____

5. What happens to macroscopic properties *at equilibrium*? _____

6. How do the rates of the forward and reverse reaction compare at equilibrium? _____

7. Do the forward and reverse reactions stop at equilibrium? _____
8. What can be said about the concentrations of all reactants and products *at equilibrium*?

9. Why is chemical equilibrium called *dynamic equilibrium*? _____

10. Given the reaction: $A + B \rightleftharpoons C + D$

When 1.0 mole of A is combined with 1.0 mole of B, an equilibrium is established in which $[A] = 0.2 \text{ M}$, $[B] = 0.2 \text{ M}$, $[C] = 0.8 \text{ M}$ and $[D] = 0.8 \text{ M}$

If, at the same temperature, 1.0 mole of C and 1.0 mole of D is combined. When equilibrium is established, determine what the following concentrations will be:

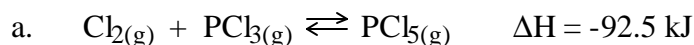
$[A] = \underline{\hspace{2cm}} \text{ M}$, $[B] = \underline{\hspace{2cm}} \text{ M}$, $[C] = \underline{\hspace{2cm}} \text{ M}$ and $[D] = \underline{\hspace{2cm}} \text{ M}$

11. Given sufficient activation energy, a system *not at equilibrium* will eventually move toward _____.

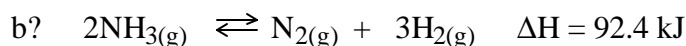
12. Systems will tend toward a position of _____ *enthalpy*.

13. Systems will tend toward a position of _____ *entropy*.

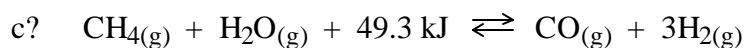
14. Tell whether each of the following is *endothermic* or *exothermic* and state which has *minimum enthalpy*, the *reactants* or the *products*:



_____ thermic and the _____ have *minimum enthalpy*.



_____ thermic and the _____ have *minimum enthalpy*.



_____ thermic and the _____ have *minimum enthalpy*.

15. If the reaction: $\text{Cl}_2(\text{aq}) \rightleftharpoons \text{Cl}_2(\text{g}) \quad \Delta H = +25 \text{ kJ}$

was proceeding to the *right*, the enthalpy would be _____ing. Is this a *favourable* change? _____.

16? If the reaction: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + 92.4 \text{ kJ}$

was proceeding to the *right*, the enthalpy would be _____ing. Is this a *favourable* change? _____.

17. For each of the following, decide whether the *reactants* or the *products* have *greater entropy*:

a) $I_{2(s)} \rightleftharpoons I_{2(g)}$ The _____ have greater entropy.

b) $4PH_{3(g)} \rightleftharpoons P_{4(g)} + 6H_{2(g)}$

The _____ have greater entropy.

c) $NH_{3(g)} \rightleftharpoons NH_{3(aq)}$

The _____ have greater entropy.

18. When the two tendencies *oppose each other* (one favours reactants, the other favours products), the reaction will _____

Processes in which *both* the tendency toward *minimum enthalpy* and toward *maximum entropy* favour the *products*, will _____

Processes in which *both* the tendency toward *minimum enthalpy* and toward *maximum entropy* favour the *reactants*, will _____

19. For each of the following reactions decide which has *minimum enthalpy* (reactants or products), which has *maximum entropy* (reactants or products), and if the reactants are mixed, what will happen? (go to completion/ reach a state of equilibrium/not occur at all).

a) $4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g)} + 114.4 \text{ kJ}$

The _____ have minimum enthalpy.

The _____ have maximum entropy.

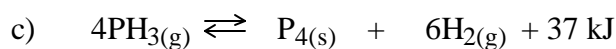
If HCl + O₂ are put together, what should happen?(go to completion/ reach a state of equilibrium/not occur at all)

b) $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(g)}; \Delta H = 42.6 \text{ kJ}$

The _____ have minimum enthalpy.

How does the entropy of the reactants and products compare? _____

If CO_{2(g)} + H_{2(g)} were put in a flask, what should happen?(go to completion/ reach a state of equilibrium/not occur at all)



The _____ has/have minimum enthalpy.

The _____ has/have maximum entropy.

If $\text{PH}_3(\text{g})$ was put in a flask? what should happen? (go to completion/ reach a state of equilibrium/not occur at all)

20. Do systems always reach *minimum enthalpy* at equilibrium? _____

Explain. _____

21. Do systems always reach *maximum entropy* at equilibrium? _____

Explain. _____

22. A "heat term" in a chemical equation shows what is happening to the _____

and really has nothing to do with the _____

(Answers are either entropy or enthalpy)

23. As a reaction approaches equilibrium, the rate of the forward reaction _____,

while the rate of the reverse reaction _____.

Once equilibrium is reached, the rates become _____

24. Consider the reaction: $\text{BaCO}_3(\text{s}) + \text{heat} \rightleftharpoons \text{BaO}(\text{s}) + \text{CO}_2(\text{g})$

Which one of the following observations will indicate that the reaction has most likely achieved *equilibrium*?

- a) The mass of the system becomes constant
- b) The concentration of $\text{BaO}(\text{s})$ becomes constant
- c) All the BaCO_3 is consumed.
- d) The gas pressure of the system becomes constant

Your answer is _____. Explain why. _____

25. Consider the following reaction: $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{FeSCN}^{2+}(\text{aq})$

A solution of $\text{Fe}(\text{NO}_3)_3$ is added to a solution of KSCN . As equilibrium is being established, the $[\text{Fe}^{3+}]$ is _____ and the $[\text{FeSCN}^{2+}]$ _____

26. A system has reached equilibrium when:

- a) maximum entropy has been achieved
- b) minimum enthalpy has been achieved
- c) the rate of the forward reaction and reverse reaction is zero
- d) the concentrations of reactants and products have stopped changing

Your answer is _____. Explain why _____

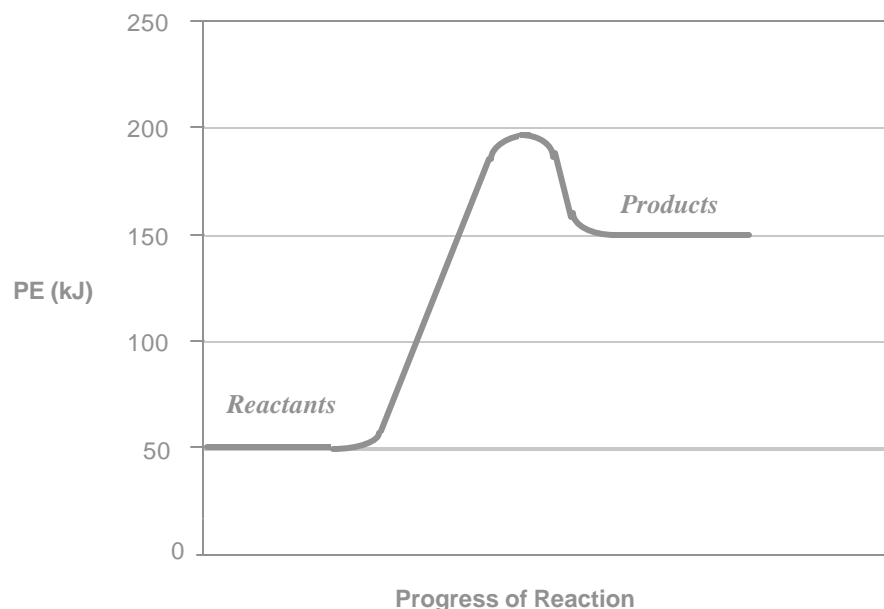
27. Equilibrium is achieved when reactant and product concentrations are (equal/constant/zero)

28. In a particular chemical reaction, $\Delta H = +100$ kJ. When equilibrium has been established, it is found that a significant amount of product has formed, even though there is still some reactants left.

What has happened to **entropy** as this reaction was taking place? _____

Explain how you arrived at your answer _____

29. Given the following potential energy diagram for a reaction:



Explain in terms of enthalpy and entropy, how you could end up with a fairly high ratio of products to reactants. _____