# 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: $A + B \rightleftarrows C + D$

When 1.0 mole of A is combined with 1.0 mole of B, an equilibrium is established in which [A] = 0.2 M, [B] = 0.2 M , [C] = 0.8 M and [D] = 0.8 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] =_____M, [B] = _____ M , [C] = _____ M and [D] = _____ 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*:

a. $Cl_{2(g)} + PCl_{3(g)} \rightleftarrows PCl_{5(g)}$ $\Delta H = -92.5$ kJ

_____thermic and the _____ have *minimum enthalpy.*

b? $2NH_{3(g)} \rightleftarrows N_{2(g)} + 3H_{2(g)}$ $\Delta H = 92.4$ kJ

_____thermic and the _____ have *minimum enthalpy.*

c? $CH_{4(g)} + H_2O_{(g)} + 49.3$ kJ $\rightleftarrows CO_{(g)} + 3H_{2(g)}$

_____thermic and the _____ have *minimum enthalpy.*

15. If the reaction: $Cl_{2(aq)} \rightleftarrows Cl_{2(g)}$ $\Delta H = +25$ kJ

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

16? If the reaction: $N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} + 92.4$ 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) $I_{2(s)} \rightleftarrows I_{2(g)}$ The _____ have greater entropy.

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

The _____have greater entropy.

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

The _____have greater entropy.

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

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

Processes in which ***<u>both</u>*** the tendency toward ***minimum enthalpy*** and toward ***maximum entropy*** favour the ***<u>reactants</u>***, 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) $4HCl_{(g)} + O_{2(g)} \rightleftarrows 2H_2O_{(g)} + 2Cl_{2(g)} + 114.4\ kJ$

The _____ have minimum enthalpy.

The _____ have maximum entropy.

If HCl + $O_2$ are put together, what should happen?(go to completion/ reach a state of equilibrium/not occur at all)

_____

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

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)

_____

c) $4PH_{3(g)} \rightleftarrows P_{4(s)} + 6H_{2(g)} + 37\ kJ$

The _____ has/have minimum enthalpy.

The _____ has/have maximum entropy.

If $PH_{3(g)}$ 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: $BaCO_{3(s)} + heat \rightleftarrows BaO_{(s)} + CO_{2(g)}$

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 $BaO_{(s)}$ 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: $Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{2+}_{(aq)}$

A solution of $Fe(NO_3)_3$ is added to a solution of KSCN. As equilibrium is being established, the $[Fe^{3+}]$ is _____ and the $[FeSCN^{2+}]$ _____

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)

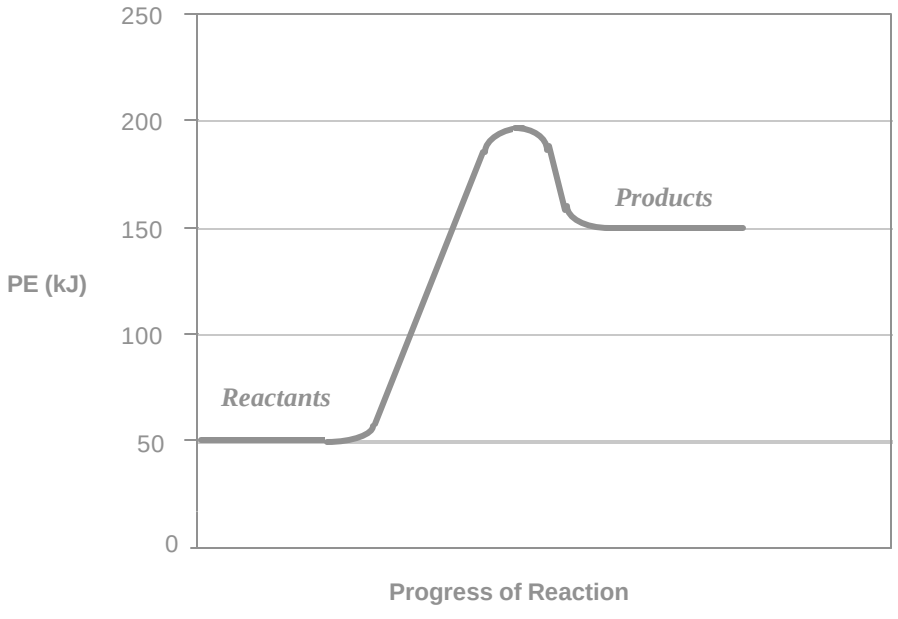
_____

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. _____