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

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

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

13. 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.*

14.   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? _____.

15.   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? _____.

16.   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.

17.   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 _____

18.   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) $4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} ++ 2Cl_{2(g)} + 114.4$ 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
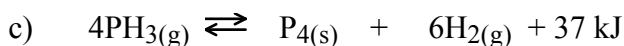   equilibrium/not occur at all)

         _____

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

        _____

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

     Explain. _____

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

     Explain. _____

21. 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)

22. 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 _____

23. 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 (or concentration of gas) of the system becomes constant.

     Your answer is _____. Explain why._____

     _____

24. 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 $[FeSCN^{2+}]$ _____