Your name: _____   TF's name:_____ Discussion Day/Time: _____

Things you should know when you leave Discussion today:
- Acid Base Reactions
  - Memorize common Acids and Bases table 6.13 on page 194 of Mahaffy book.
- Oxidation Reduction Reactions
  - Oxidation is <u>loss</u> of electrons (acts as a reducing agent)
  - Reduction is <u>gain</u> of electrons (acts as a oxidizing agent)

1. Balance and Answer the following about the oxidation reduction reaction given below

$$Zn(s) \ + \ Cu^+(aq) \rightarrow Zn^{2+}(aq) + \ Cu(s)$$
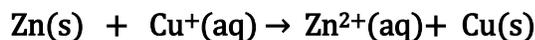
 Half Reaction:

Identify if your half reaction is **oxidation** or **reduction:**

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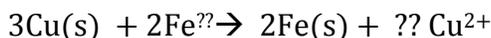
Oxidized Reactant:

Reduced Reactant:

Oxidizing Agent:

Reducing Agent:

How many moles of the electrons are transferred per mole of reaction?

2. Complete the following reaction:

$$3Cu(s) \ + 2Fe^{??} \rightarrow \ 2Fe(s) + \ ?? \ Cu^{2+}$$

   a) How many moles of the electrons are transferred per mole of reaction?

3. Give a definition and an example for **Brønsted-Lowry acid**:

4. Give a definition and an example for **Lewis base:**

5. Ammonia, NH_3, is a useful household cleaner, fertilizer, and antimicrobial compound.

   a) If NH_3 acts as an acid in water, write the balanced chemical equation. Label the Brønsted-Lowry acid and its conjugates.

   b) If NH_3 acts as a base in water, write the balanced chemical equation. Label the Brønsted-Lowry acid and its conjugates.

   c) A small amount of aluminum nitrate is added to the products of the acid/base reaction in (b) and a precipitate forms. Write the balanced, net-ionic equation for the precipitation.

   d) Ammonia is the conjugate acid in the reaction of the strong base amide, NH_2^- with water. Write the acid/base reaction of amide, NH_2^-, with water and label the Brønsted-Lowry acid reactant in this reaction.

6. Consider the four acid/base reactions below.

   In the reaction $NH_3(aq) + H_2CO_3(aq) \rightarrow NH_4^+(aq) + HCO_3^-(aq)$, the conjugate base is _____ .

   In the reaction $CH_3COO^-(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + OH^-(aq)$, the conjugate acid is _____ .

   In the reaction $Fe^{2+}(aq) + 6\ H_2O(l) \rightarrow [Fe(H_2O)_6]^{2+}(aq)$, the Lewis acid is _____ .

   Lewis base is_____

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7. List all strong acids you know. Why do we call them strong?

    a) How many hydronium ions are in 1.5L of 0.20M solution of HCl?

8. The 0.10 mole of sulfuric acid in 50.0 mL of water produces the concentration of the hydronium ion to be 2.5 M. If you know that sulfuric acid is a strong acid and consider that acids always donate one proton at a time according to the following reactions:

$$H_2SO_4 (aq) + H_2O(l) \leftrightarrows H_3O^+(aq) + HSO_4^- (aq)$$
$$HSO_4^-(aq) + H_2O(l) \leftrightarrows H_3O^+(aq) + SO_4^{2-}(aq)$$
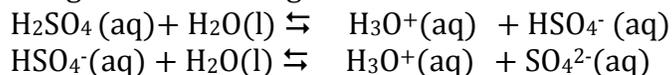
Is HSO_4^- acting as a strong acid or a weak acid? Prove your answer.

9. I add 5.00 moles of solid $NaNO_3$ to 500. mL of a 1.00 M $Pb(NO_3)_2$ solution, which does not change the volume. I then pour in 500. mL of hydrochloric acid that is 0.500 M. I let the solution come to equilibrium. (Remember that nitric acid and hydrochloric acid are both strong acids)

    a. What is the final molar concentration of H_3O^+ ion in solution?(Answer:0.250M)

    b. What is final molar concentration of Cl^- ion?

    c. What is final molar concentration of Pb^{2+} ion?(Answer: 0.375M)

    d. What is the final molar concentration of the nitrate ion? ?(Answer: 6.00M)

10. When the two compounds below are mixed, circle the one that behaves as a Lewis base

a) H_2O: NH_4^+

b)   :NH_3 H_2O

c) CO_3^{2-} H_2O

d) BF_3 :NH_3

11. Give an example of neutralization reaction:

12. We are going to cool 28g of water from 10.°C down to 0.0°C (specific heat of water is 4.2 J/(K·g)). During this process of cooling what is true?

    a. Heat is absorbed by the water or Heat is released by the water (choose one)
    b. $q_{system} < 0$, $q_{system} > 0$, $q_{system} = 0$ (choose one)

    c. $q_{surroundings} < 0$, $q_{surroundings} > 0$, $q_{surroundings} = 0$ (choose one)

    d. What is q_{system} in Joules? ?(Answer:-1.2kJ)

    e. What is $q_{surroundings}$ Joules?

13. Define **enthalpy of fusion $\Delta_{fus}H$**:

14. We are going to freeze 28g of water at 0.0°C down to 0.0°C ice ($\Delta_{fus}H$= 6.00 kJ/mol; melting). During this process circle all that apply:

    a) There is a net gain in the number of H-bonds   or   There is a net loss in the number of H-bonds
    b) Heat is absorbed by the water   or   Heat is released by the water
    c) Process is exothermic or   Process is endothermic
    d) $q_{system} < 0$, $q_{system} > 0$, $q_{system} = 0$ (choose one)

    e) $q_{surroundings} < 0$, $q_{surroundings} > 0$, $q_{surroundings} = 0$ (choose one)

    f) What is a temperature change of the system?

    g) Calculate q_{system} in Joules? ?(Answer:-9.3kJ)

    h) What is $q_{surroundings}$ in Joules?

15. (at home)Calculate the heat (q) in joules that is involved in cooling 28g of liquid water starting at 10. °C to ice at 0. °C. ?(Answer:-11kJ)

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<u>Practice problems:</u>

16. Calculate the energy needed, in kJ, to heat 36 g of water from 50. ºC to 100. ºC and then to completely vaporize it to steam at 100 ºC. The specific heat of water is 4.18 J/(K· g) and its enthalpy change of vaporization is 40.7 kJ/mol. (Answer:89kJ)

17. If 42. kJ of energy is add to 1.0 kg of water (C = 4.184 J/(g·K)), initially at 25ºC.

    a) What is the final temperature of the water (in K)? ?(Answer:308)

    b) The same amount of energy was added to 2.0 kg of an unknown substance and its temperature increased by 6ºC. What is the specific heat of the unknown substance (in J/(g·K))?(Answer:3.5)

18. You are given 2L of a 0.05 M HCl solution. You are also given a 0.5M solution of barium hydroxide. What volume (in L) of the $Ba(OH)_2$(aq) solution is required to completely react with the HCl solution, with no HCl or $Ba(OH)_2$ remaining in solution?(Answer:100mL)

19. If 1L of 0.35 M solution of the unknown acid HA produces 0.035M concentration of the hydronium ion what is the percent of the acid reacted? Is the unknown acid a strong or weak electrolyte? (Answer:10.%)

20. How many grams of $Ba(OH)_2$ is needed to be mixed with 220 ml of water to produce 0.045M solution of hydroxide . (Answer: 0.85g)

21. Calculate the sodium ion concentration when 70. mL of 3.0 M sodium carbonate is added to 30. mL of 1.0 M sodium nitrate.(Answer: 4.5M)

    a) To the sodium carbonate and sodium nitrate solution, you add 0.20 moles of solid $BaCl_2$. What is the final concentration of each of the ions in the solution? Assume the solid $BaCl_2$ does not change the volume.
    (Answer:0.30, 0, 0.10)

22. A 0.3mol sample of an acid HA is added to 500. mL of water and only 0.01% of the acid reacts. How many moles of HA, A⁻, H_3O^+, and H_2O are present at the end of the reaction?(report your answer to one significant figure) (Answer: $3 \cdot 10^{-5} mol$, $3 \cdot 10^{-5} mol$, 0.3mol, 30mol)

<u>In preparation for next week material not part of exam2.</u>

23. During the chemical reaction thermometer in a beaker showed the increase in temperature by 10.°C. Choose all that apply:

$q_{sys} \; < \; = \; > \; 0$ $q_{sur} \; < \; = \; > \; 0$ $w \; < \; = \; > \; 0$ $\Delta T_{sys} \; < \; = \; > \; 0$ $\Delta T_{sur} \; < \; = \; > 0$

24. Reaction takes place in the balloon. During the reaction balloon expands. Choose all that apply:

$q_{sys} \; < \; = \; > \; 0$ $q_{sur} \; < \; = \; > \; 0$ $w \; < \; = \; > \; 0$ $\Delta T_{sys} \; < \; = \; > \; 0$ $\Delta T_{sur} \; < \; = \; > \; 0$

25. A combustion reaction takes place in the balloon. During the reaction balloon expands. Choose all that apply:

$q_{sys} \; < \; = \; > \; 0$ $q_{sur} \; < \; = \; > \; 0$ $w \; < \; = \; > \; 0$ $\Delta T_{sys} \; < \; = \; > \; 0$ $\Delta T_{sur} \; < \; = \; > \; 0$

Diagrams vs. Graphs

Both diagrams and graphs are used in chemistry to help represent physical phenomena. The most common graphs show the relationship of two variables, such as distance and time, or frequency and wavelength. Diagrams, however, are a bit tricker. Diagrams can come in a number of different structures and can be used to show information about one thing, or about a lot of different reationships at once.
One of the simplist diagrams you will see in chemistry is a one dimentional scale, showing values of only one variable. An example of this type of diagram is one you have seen on your computer – a volume scale. This diagram shows you the relative level of volume on your computer. While there are no values shown on this diagram, you know that the higher the knob is, the greater the volume and visa versa. In chemistry, we use a similar diagram structure when we talk about energy and different chemical reations. These are called: *Energy Diagrams*. Interactions in chemistry is a change between energy values. Therefore, the arrows on the diagram shows this change between a range of two energy values.

Energy Diagrams

In chemistry, we use a vertical scale to show energy values. In the figures below, you'll notice that the arrow for our energy scale is pointing upwards, indicating that the scale can increase infinitely upwards if necessary.   Next to that scale, we use horizontal lines and arrows to show either a particular value of energy, or a change in energy. The size of the horizontal lines do not matter, only their vertal location along the scale. The size of the vertical arrows, however, show a specific range on the energy scale and represents the *change in energy* associated with the process on the diagram.

For example, Figure (a) shows two different states, A and B, with their associated energies, 100 kJ and 200 kJ, respectively. The states are drawn as horizontal lines, or platforms, so that we can use them to draw different changes in energy. Here we can see that B has greater energy than A. In the middle diagram Figure (b), we have drawn an arrow pointing from the lower energy level to the higher one. This means that with some sort of physical phenomenon, like a chemical reaction, during which state "A" is tranformed into state "B" (the reaction would be written as A → B). During that process, is the energy increased from 100 kJ to 200 kJ. The change in energy, ΔE, is calculated as the different between the final energy and intial energy:

$$\Delta E_{\text{A to B}} = E_{\text{final}} - E_{\text{initial}} = 200 \text{ kJ} - 100 \text{ kJ} = +100 \text{ kJ}.$$

The diagram on the right Figure (c) shows the reverse of this phenomenon (where B is the initial state and A is the final state), where the energy decreases from 200 kJ to 100 kJ ($\Delta E_{\text{B to A}} = -100$ kJ).

Draw energy diagrams for each of the following situations:

1. The energy of "B" is 10 kJ greater than the energy of "A". "A" is 30 kJ ($E_A = 30$ kJ).
   a. Draw in the energy levels of A and B on the diagram.
   b. Write the "reaction" for the process of A becoming B.
   c. On your diagram, draw the arrow corresponding to $\Delta E_{\text{A to B}}$. Is this process endothermic or exothermic?
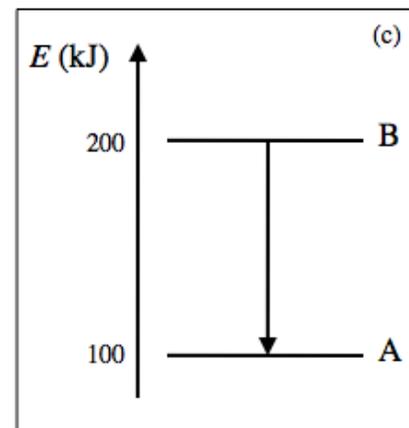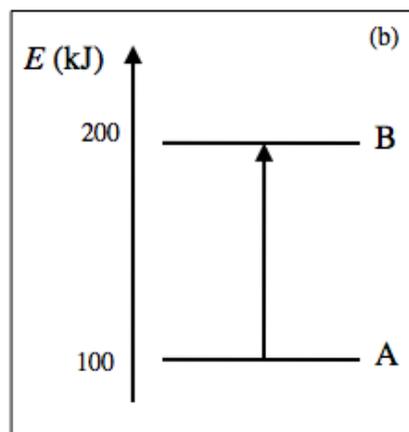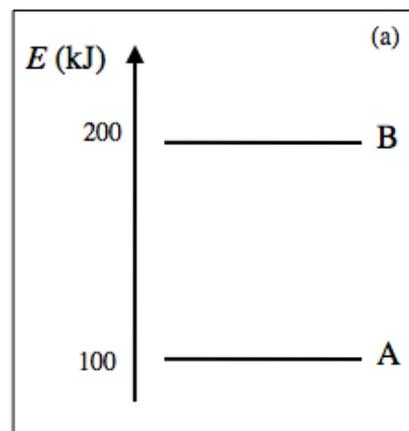
2. The energy of "C" is 25 kJ greater than the energy of "D". "D" is 0 kJ ($E_D = 0$ kJ).
   a. Draw in the energy levels of C and D on the diagram.
   b. Write the "reaction" for the process of C becoming D.
   c. On your diagram, draw the arrow corresponding to
      $\Delta E_{C\ to\ D}$. Is this process endothermic or exothermic?

3. Below are energy transitions between energy levels
   F, G, H and I. Using these transitions, draw one diagram
   that shows all four energy levels in the appropriate order and
   with the appropriate energy values.

   a) $E_F = 10$ kJ
   b) $\Delta E_{I\ to\ F} = +10$ kJ
   c) $\Delta E_{I\ to\ H} = +20$ kJ
   d) $\Delta E_{F\ to\ G} = +5$ kJ
   e) $\Delta E_{G\ to\ I} = -15$ kJ

   Reading Energy Diagrams: From the diagram given on the right, answer the following questions:
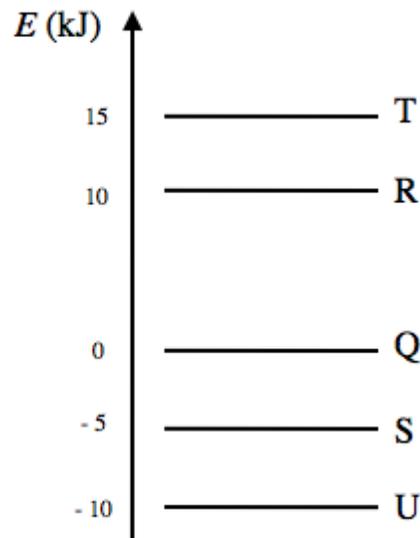
1. What is the change in energy from Q and S? ($\Delta E_{Q\ to\ S}$).
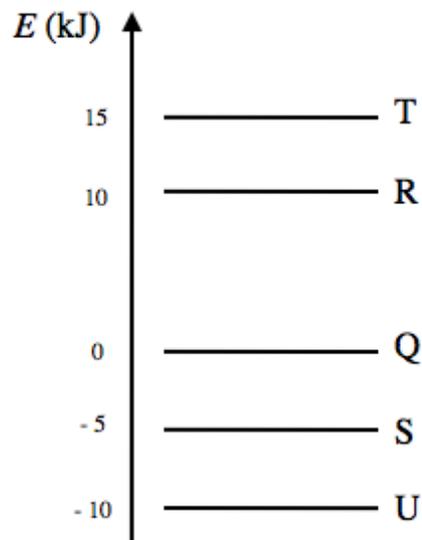
2. What is the change in energy from R and T? ($\Delta E_{R\ to\ T}$)

E (kJ)

15   ———— T

10   ———— R

0   ———— Q

-5   ———— S

-10   ———— U

E (kJ)

15	———— T
10	———— R
0	———— Q
-5	———— S
-10	———— U

3. What transitions result in –20 kJ? Write the 'reactions' for each.

4. What transitions result in +15 kJ?

Make your own diagram

1. Burning one mole of carbon, $C(s)$, in oxygen, $O_2(g)$, to form carbon dioxide, $CO_2(g)$, releases 400 kJ of energy. Draw an energy level diagram to depict this transformation. What is the "initial state"? What is the "final state"? Is the process endothermic or exothermic?

### Energy Diagrams: Endothermic and Exothermic Reactions
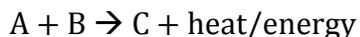
Chemical Reactions

Chemical reactions are always accompanied by a change in internal energy, ΔU, which is the difference between the internal energy of the reactants ($U_{initial}$) and the internal energy of the products ΔU_{final}):

$$\Delta U = U_{final} - U_{initial}$$

In some cases, the chemical reaction (the 'system') releases energy to the surroundings – this is called an *exothermic* reaction. In this case, the energy of the products is lower than that of the reactants, as can be seen in the diagram on the right.

Other than using the diagram, there are a few other ways of indicating that a reaction is exothermic. "Energy is released (from system to surroundings)", $\Delta U < 0$, and "heat is a product" are all ways of indicating that a process is exothermic. Some people also write a chemical reaction including energy/heat:

E (kJ)
Reactants
ΔU
Products
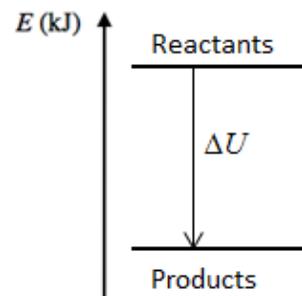
A + B → C + heat/energy

Though writing a reaction like this is not rigororously correct, as heat/energy are not chemical species and therefore cannot be reactants or products, this can help you visualize whether heat is released by a reaction (exothermic) or absorbed by a reaction (endothermic).

In an *endothermic* reaction, the reverse occurs and energy is absorbed by the system. In this case, the overall energy of the system increases throughout the reaction and the resulting energy of the products is greater than that of the reactants.

1. Draw the diagram, like the one above, for an endothermic reaction.
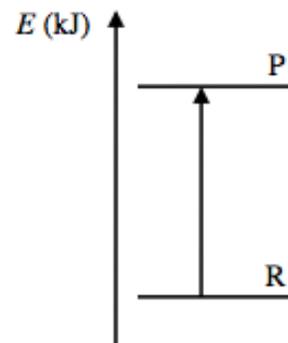
2. Write a chemical reaction equation, like the one above, for an endothermic reaction.

3. In the discussion above, we listed four other ways of indicating the flow of energy in reactions in addition to drawing diagrams. Write this list for an endothermic reaction.

4. Did the overall energy of the reaction on the right increase or decrease? What kind of a reaction does this energy diagram represent?