CHEMISTRY REVIEW FOR AP BIOLOGY

Answer Key

Complete the following and be knowledgeable of the concepts on the first day of school.

A. KINETICS = involves factors that affect the rate of a chemical reaction.

1. Explain why the following situations are true with regard to the Collision Theory.

- **Sugar dissolves in hot tea more rapidly than in iced tea.**

Hot tea contains molecules with higher average kinetic energy allowing for more collisions between solute and solvent particles increasing the rate of dissolving.

- **Wood burns better in pure oxygen than in air.**

Pure oxygen (100%O_2) has a higher concentration of oxygen than air (only 20%O_2) allowing for more molecules to collide with wood during burning.

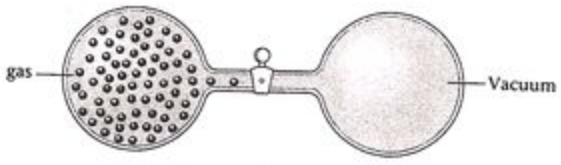
- **Refrigeration delays the spoilage of food?**

Lowering the temperature lowers the number of collisions between particles responsible for the action of enzymes that spoil food.

B. THERMODYNAMICS = concerned with heat and temperature and their relation to energy and work; the study of the driving forces of nature.

For example, a log burning in a fireplace produces ashes and heat energy. We would never see the reverse where ashes absorb heat from air to reconstruct the log.

Consider another example. A gas is trapped in one end of a vessel as shown below.



When the valve is opened, what always happens? The gas spreads evenly throughout the entire container. We would never see the particles all move to the other side.

Scientists have discovered two important driving forces that make reactions happen:

1. enthalpy (H) = the potential energy within the chemical bonds.

2. entropy (S) = the disorder of the particles.

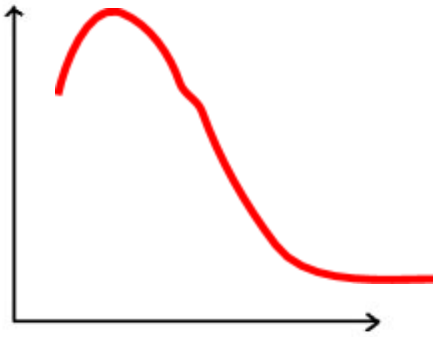
In both cases, the driving forces in nature involve the spread of both enthalpy and entropy. Enthalpy (energy) spread disperses energy and occurs during exothermic reactions. Entropy (matter) spread occurs when there is an increase in disorder. Both forces bring stability to a system.

1. Energy spread occurs when concentrated energy disperses widely.

A. Would energy spread be occurring in endothermic or exothermic reactions? Explain.

Exothermic reactions release energy allowing energy to spread out.

B. Draw a potential energy diagram with the axis to illustrate this type of reaction.



C. In this situation would the value of $\triangle H$ be negative or positive? Negative value

$$\triangle H = H_{final} - H_{initial}$$

D. In this situation, which has more enthalpy, the reactants or products? Which has less enthalpy? The reactants have more enthalpy and the products have less enthalpy.

E. In this situation, which has more stability, the reactants or products? Which has less stability? Substances with less enthalpy are more stable. Nature favors less enthalpy. The reactants have less stability and the products are more stable.

F. Explain, in terms of stability, why when two atoms, let's say 2 fluorine atoms combine to form a chemical bond, energy is released. A fluorine atom has an incomplete valence shell and in nature this results in less stability. As soon as a bond is formed, the sharing of electrons allows for a complete valence shell increasing stability (less enthalpy). This describes an exothermic change.

2. Matter spread means molecules of a substance spread out and occupy larger volume.

A. Would matter spread be occurring in reactions of increasing or decreasing entropy? Explain. Matter spread would occur in changes of increasing entropy. Spreading out particles allows for more disorder. Nature favors more entropy.

B. In this situation would the value of $\triangle S$ be positive or negative?

$\triangle S = S_{final} - S_{initial}$

The value is positive since the final products have more entropy.

C. In this situation, which has more entropy, the reactants or products? Which has less entropy? The reactants have less entropy and the products have more entropy.

D. In this situation, which has more stability, the reactants or products? Which has less stability? The reactants have less stability and the products have more stability. Nature favors more entropy and more entropy means more stability.

FINAL STATEMENT

In nature, reactions move toward less enthalpy (exothermic) with the sign of $\triangle H$ being negative and more entropy (disorder) with the sign of $\triangle S$ being positive.

With regard to this final statement, and in terms of enthalpy and entropy, explain why a burning log could never occur in reverse.

A burning log is exothermic, releasing heat and forming products with less enthalpy. Water and carbon dioxide have less enthalpy than the wood and oxygen that reacted. A burning log starts with solid wood and oxygen gas and produces carbon dioxide gas, water vapor and carbon ashes. The products contain more entropy than the wood. Because the burning log is exothermic for less enthalpy and releases gas products for more entropy, nature would never be able to reverse this reaction.

The combined effect of the changes in enthalpy and entropy is called Free Energy Change or Gibbs Free Energy. When ΔG is negative, the rules of nature are followed (less enthalpy but more entropy) and the reaction occurs. Check line 1 of the chart below.

$$\Delta G = \Delta H - T\Delta S$$

Complete the chart for the different situations by plugging the sign for ΔH and ΔS and stating the sign of ΔG.

SITUATION ΔH	SITUATION ΔS	SIGN OF ΔG	REACTION OCCURS? YES OR NO
- (neg)	+ (pos)	-	Yes (called spontaneous)
+ (pos)	- (neg)	+	No (called non-spontaneous)
- (neg)	- (neg)	Neg only at low temps	Yes at low temps
+ (pos)	+ (pos)	Neg only at high temps	Yes at high temps

C. <u>BONDING</u> = the relationship between atoms to obtain a complete valence shell. Bonds include covalent (sharing electrons), ionic (transfer electrons) and metallic (mobile electrons). This is not to be confused with IMFAs (intermolecular forces of attraction) which include hydrogen bonding (extreme dipole), molecule-ion, and van der waals.

1. Why does solid magnesium, Mg(s), conduct electricity but solid magnesium oxide, MgO(s) does not? Solid Mg(s) contains a metallic bond with mobile electrons allowing for conduction of electricity. Solid MgO(s) contains an ionic bond with no mobile charged particles and therefore cannot conduct electricity.

2. Put the following substances in order of increasing melting point. Justify your reasoning by stating the type of bonding or IMFA in each.

$H_2O_{(s)}$ $NaCl_{(s)}$ $Cu_{(s)}$ $F_{2(g)}$

$F_2(g)$ $H_2O(s)$ NaCl(s) Cu(s)

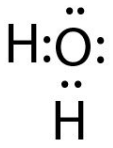
(lowest m.p.) (highest)

van der waals hydrogen bonding ionic bonding metallic bonding

3. Draw the Lewis dot formula of any substance with ionic bonding and another with covalent bonding. Label each to show which is ionic and which is covalent.

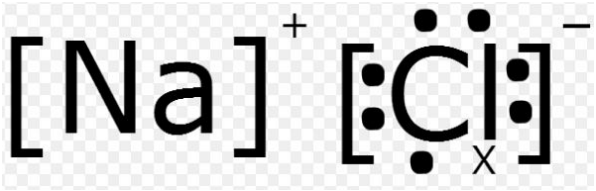
COVALENT

(polar covalent molecule with polar covalent bonding)



IONIC

(sodium loses one electron and becomes positive and chlorine loses one electron and becomes negative)



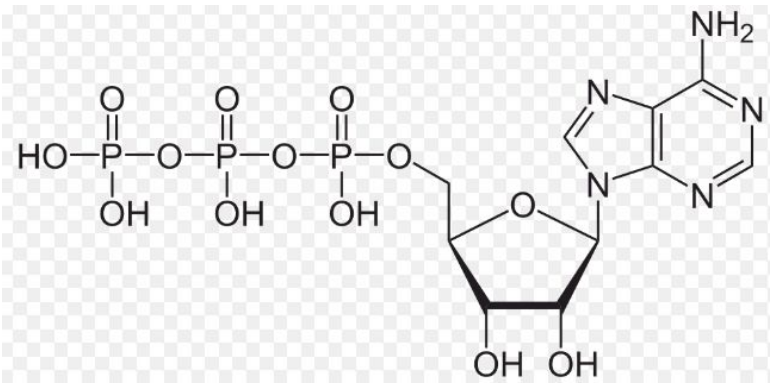
4. Explain the trend in boiling point in terms of intermolecular attractions.

GAS	RADIUS (A)	BOILING POINT (^{O}C)
He	0.93	-268.9
Ne	1.12	-245.9
Ar	1.54	-185.7
Kr	1.69	-152.9
Xe	1.90	-107.1

All noble gases are considered nonpolar containing weak van der waals forces. The rule of strength is the more electrons the stronger the van der waals. Helium is the smallest noble gas and has the weakest van der waals and would therefore have the lowest boiling point. Xenon has the most electrons, the strongest van der waals and therefore the highest boiling point.

D. ORGANIC CHEMISTRY

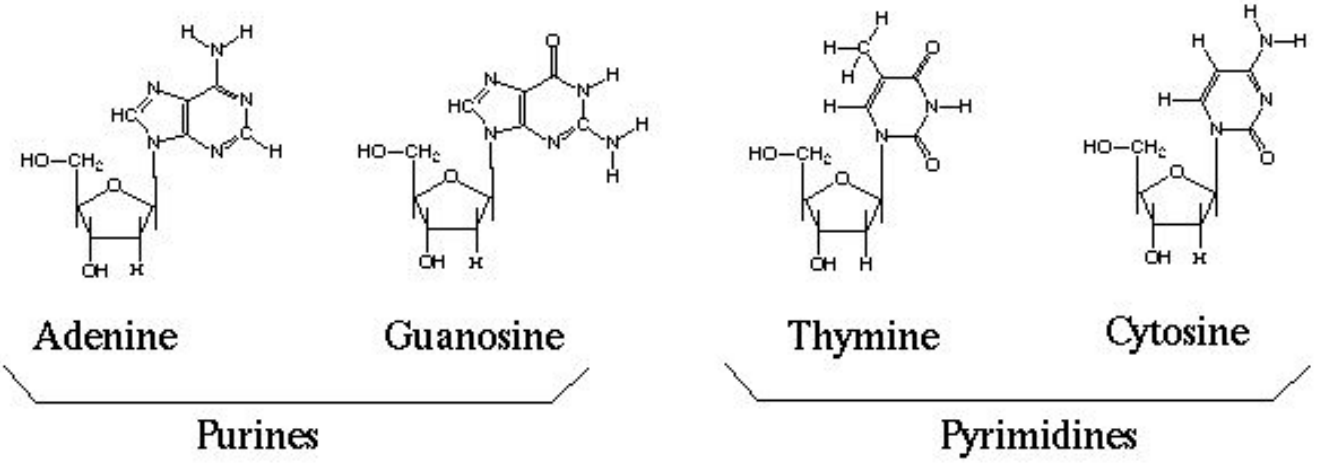
1. **Circle, and label to identify all the functional groups in the diagram below of an ATP molecule. Should know phosphate, amine, hydroxyl, ether, phosphoester, carboxyl, carbonyl**



2. List the structural differences that you observe between purines and pyrimidines.

Answers will vary.

The Nucleotides of DNA

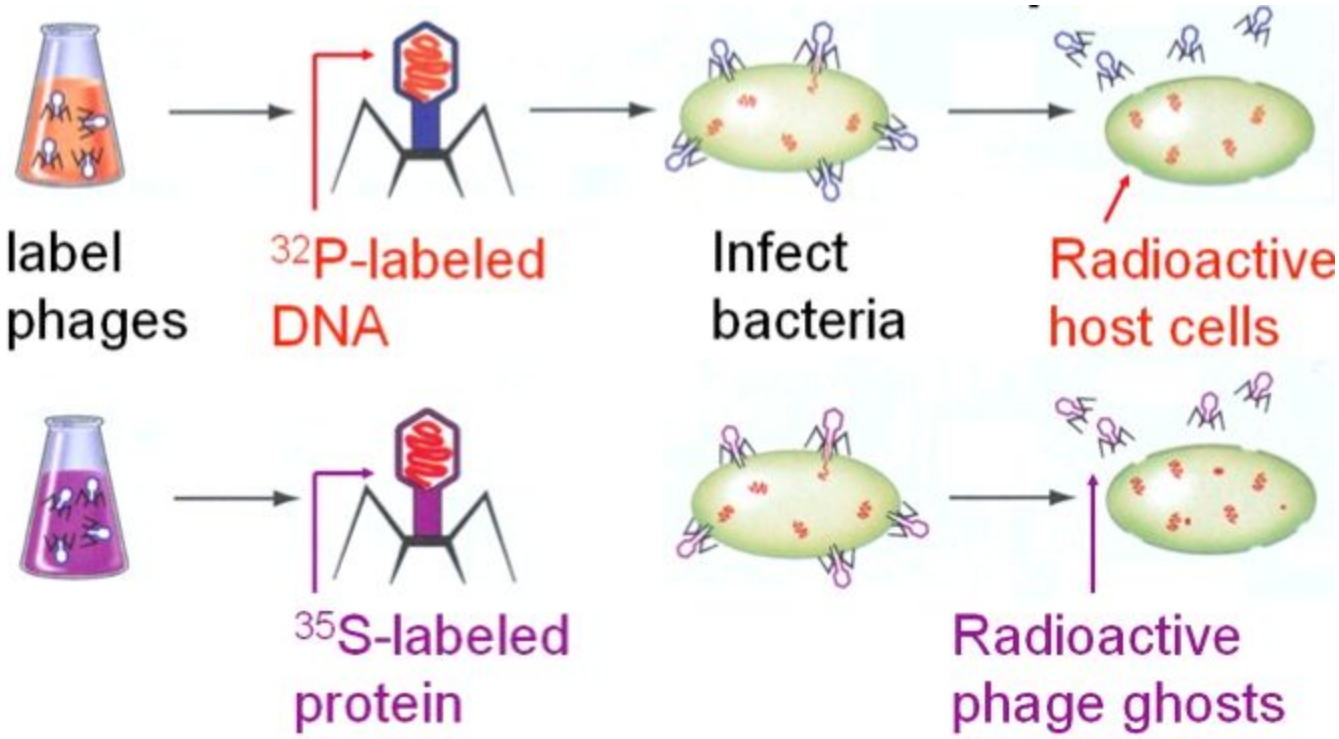


Adenine Guanosine Thymine Cytosine

Purines Pyrimidines

E. NUCLEAR CHEMISTRY AND RADIOACTIVITY.

In 1952, a famous experiment was conducted by Alfred Hershey and Martha Chase at the Cold Spring Harbor Laboratory. Their goal was to confirm that DNA was in fact the genetic material and not the protein molecule as many scientists assumed due to the complexity of proteins. They used two radioisotopes in the experiment as shown in the diagram below. Note: a phage is a virus that infects and replicates in a bacterial cell.



1. Complete the chart by stating the number of protons, neutrons and electrons in each radioisotope used in the Hershey-Chase experiment

Radioisotope	# protons	# neutrons	# electrons
phosphorous-32	**15**	**17**	**15**
Sulfur-35	**16**	**19**	**16**

2. Why was it necessary to use radioisotopes in this experiment? (Hint: Think of a purpose of radioisotopes).

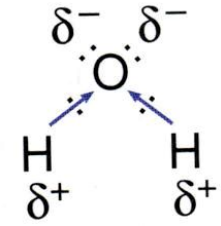
The radioisotopes were used as <u>tracers</u> to follow the movement of certain elements.

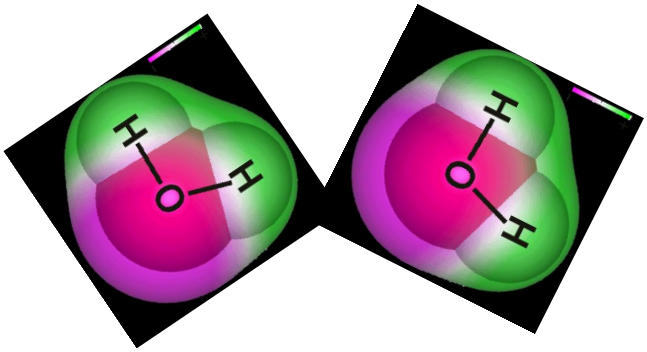
3. Why did Hershey and Chase use P-32 to label DNA but S-35 to label protein?

P-32 was used to label DNA because phosphorus is found in DNA sulfur is not. S-35 was used to label proteins because sulfur is found in proteins phosphorous is not.

F. <u>CHARACTERISTICS OF WATER</u>

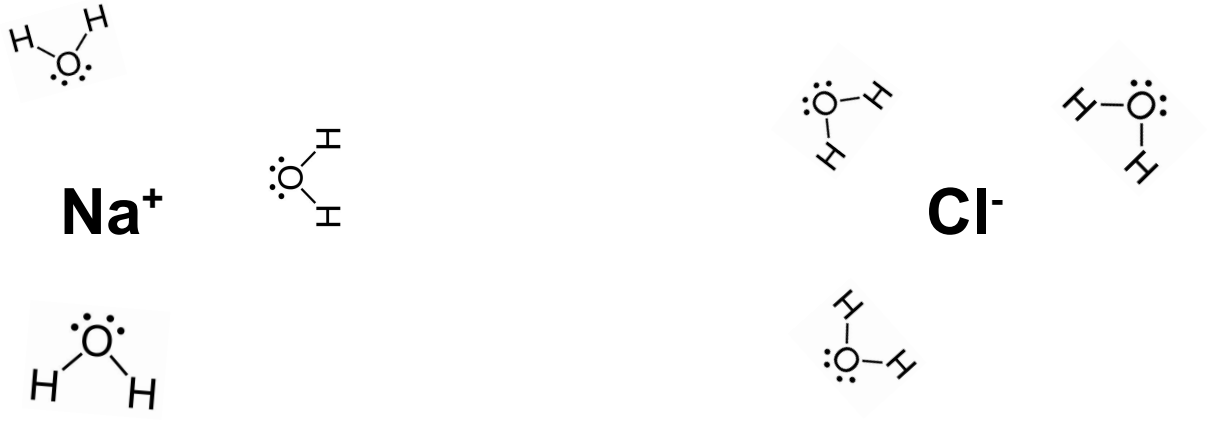
1. **Draw a Lewis dot diagram of a water molecule. Label the partial positive and the partial negative ends of the molecule. Draw second water molecule identical to and next to the first diagram. Be sure to draw the second one in the correct orientation to the first one.**





The positive end of one water molecule is attracted to the negative end of the next water molecule; shows cohesiveness of water.

2. **Draw three molecules of water in the correct orientation around each of the ions shown below.**



3. **What is the type of intermolecular force of attraction in a sample of water?**
   Hydrogen bonding; formed when water freezes and broken when water vaporizes.
4. **Define the following terms:**
   a. **Specific heat = the heat required to raise the temperature of a unit mass of a given substance by one degree.**

   b. **Heat of vaporization = the heat absorbed to vaporize a unit mass of a given substance; also known as latent heat of vaporization since the temperature of the substance does not change during this change of phase.**
   c. **Heat of fusion = the heat absorbed to melt a unit mass of a given substance; also known as latent heat of fusion since the temperature of the substance does not change during this change of phase.**

5. **What is responsible for H_2O having a boiling point of 100^{O}C and H_2S, a molecular cousin of water, having a boiling point of -60^{O}C?**
   The difference is that water contains a much stronger version of dipole attractions called hydrogen bonding whereas hydrogen sulfide has weaker dipole attractions. This is all due to the higher electronegativity of oxygen compared to sulfur.

6. **The average ocean temperature in October in New York is around 65^{O}F but the average air temperature in October in New York is around 55^{O}F? Why does the ocean water stay warm even though the air temperature is colder?**
   Water has a very high specific heat value compared to most other substances so it takes more energy to heat water as well as longer to cool off than most other substances.

7. **All aerobic organisms require oxygen for survival. Where is the oxygen for aquatic organisms? Aquatic organisms get oxygen by extracting dissolved oxygen from the water using specialized structures such as gills or diffusion through the cell membrane.**

8. **What is the relationship of temperature to the amount of dissolved oxygen in the oceans? Explain this characteristic with regard to the solubility of a gas dissolved in a liquid. (Hint: think about the gas laws). The higher the temperature the lower the amount of dissolved oxygen in the oceans. The lower the temperature the higher the dissolved oxygen. The reason is that oxygen is a gas and when heated gases expand and become less soluble in water. When cooled, gases are more soluble.**