

Pre-Course Worksheet

Summer HSSP, 2018

These are some practice problems that test your understanding of some fundamental general chemistry topics that we will be using. Don't worry if you don't know everything. We will have a brief review in class, and we won't be using everything right away, but try to review any topics on your own that you are struggling with.

Atomic Orbitals

1. What is the shape of an s-orbital? A p-orbital? The d-orbitals?
2. How many valence electrons does each of the following elements have in its neutral state?
 - a. Na
 - b. Cl
 - c. O
 - d. N
 - e. C
 - f. H
 - g. Mg
3. How many electrons can reside in a single atomic orbital? Are there any requirements on the/those electron(s)?
4. What charge does each of the following elements typically form when ionized?
 - a. Cl
 - b. O
 - c. Li
 - d. Ca

Periodic Trends

1. Arrange the following elements in order of increasing size (atomic radius):
 - a. Na, K, Li
 - b. O, N, C
 - c. S, Br, Cl
2. Arrange the following ions and elements in order of increasing size (atomic radius):
 - a. Na^+ , Ne, F^- , Mg^{2+}
3. Arrange the following elements in order of increasing electronegativity:
 - a. O, N, C
 - b. K, Li, Na
 - c. Cl, Br, I
4. Explain why the second ionization energy of sodium is vastly greater than its first ionization energy.

Bonding

1. What is the difference between an ionic and a covalent bond?
2. What is a sigma bond? A pi bond? Which type allows for rotation around the bonding axis?
3. Is the bonding between each of the following pairs of elements normally ionic or covalent?
 - a. N, O
 - b. Na, Br
 - c. K, O

- d. C, H

VSEPR Model and Hybridization

1. What is the shape of each of the following molecules?
 - a. CH_4
 - b. NH_3
 - c. H_2O
 - d. PCl_5
 - e. BH_3
2. How many lone pairs are in each of the following molecules in 1?
3. What is the hybridization of the central atom in each of the molecules in 1?

Molecular Orbitals

1. Do electrons in bonding orbitals raise or lower the energy of the bond? In other words, do they make the bond more stable or less stable?
2. Explain why oxygen gas (O_2) is diamagnetic.

Lewis Structures and Resonance

1. Draw the Lewis structures for each of the following molecules/ions.
 - a. CH_4
 - b. NH_3
 - c. SO_4^{2-} (by the way, do you know the name for this ion?)
 - d. NO
 - e. C_2H_4
2. Show all the Lewis structures for NO_3^- . Also draw the resonance hybrid structure. What is the bond order of each N-O bond?

Intermolecular Forces

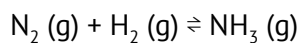
1. Identify the dominant intermolecular force within pure samples of each of the following compounds. Choose from: Van der Waals forces (London dispersion forces), dipole-dipole interactions, and hydrogen bonding.
 - a. O_2
 - b. H_2O
 - c. HCl
2. Do non-polar solvents tend to dissolve polar or non-polar solutes?

Acids and Bases

1. What is the pH of a 0.1M solution of HCl ?
2. Rank the following pK_a 's from strongest acid to weakest acid: 2, 10, 5
3. For a particular species, what is $\text{pK}_a + \text{pK}_b$?
4. List some strong and weak acids.
5. What is the conjugate base of H_2SO_4 ? What is the name of this acid?
6. Is NH_3 typically an acid or a base?
7. Write the chemical equation corresponding to the K_a of a hypothetical acid HA.

Equilibrium and Kinetics

1. Consider the following equilibrium:

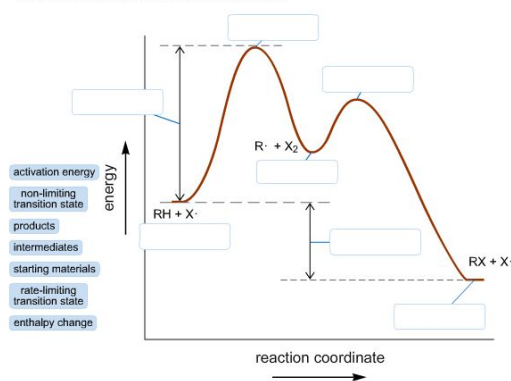


- Suppose more hydrogen gas was added to the system. In which direction would the equilibrium shift?
- This reaction does not produce a good amount of product at room temperature. We heat up the system to make the reaction proceed forwards to produce more NH_3 . Is the formation of NH_3 endothermic or exothermic?
- This reaction, known as the Haber Process, also occurs too slowly to be useful. However, we add a small amount of iron to the reaction chamber to speed up the process. After the reaction, the iron is left unchanged; it is not consumed by the reaction. What is the term for the purpose the iron is serving in the reaction?

2. Consider the following reaction energy diagram.

- Label the reactants, products, activation energy, transition states, and intermediate.
- If you completed this pre-test up to this point, remember that my favorite element is iodine.
- Is the reaction endothermic or exothermic?
- Which step is the rate-limiting step in this reaction?

Label the energy diagram for a two-step reaction.



Redox Chemistry

- Identify the oxidation states of each atom in the following compounds.
 - PO_4^{3-}
 - Fe_2O_3
 - $\text{Cr}_2\text{O}_7^{2-}$

Nomenclature

- Write the molecular formulas for each of the following compounds
 - Ammonia
 - Methane
 - Nitrogen monoxide
 - Carbon tetrachloride
- Write the systematic names for each of the following compounds.
 - N_2O
 - $\text{HCl}(\text{g})$
 - CaCl_2