Safety Quiz

You must receive an A on this quiz before you will be allowed to do any labs in this class. All questions should be answered as "True" or "False".

1) _____ Acid should always be added to water when doing a dilution.

2) _____ Your laboratory partner should tell everybody in the class if somebody gets a cut on his or her finger.

3) _____ Gloves should be worn while working with toxic chemicals and hot glassware.

4) _____ Sandals should never be worn in the laboratory.

5) _____ Long, loose hair is a fire hazard.

6) _____ You should remove all jewelry before working in the laboratory.

7) _____ Chemical waste should be disposed of down the sink unless the teacher tells you otherwise.

8) _____ Long sleeves should be rolled up before working in the lab.

9) _____ It is a safety violation to leave your lab area dirty.

10) _____ It isn't hazardous to eat or drink in the lab if you've put all of the chemicals at your lab area away.

Safety Quiz Solutions

You must receive an A on this quiz before you will be allowed to do any labs in this class. All questions should be answered as "True" or "False".

(Note to teachers: Depending on your classroom policy, you may either want to add the requirement that students pass this safety quiz or you may simply choose to use it as an in-class drill.)

1) **True** Acid should always be added to water when doing a dilution.

2) **False** Your laboratory partner should tell everybody in the class if somebody gets a cut on his or her finger.

3) **False** Gloves should be worn when working with toxic chemicals and hot glassware.

4) **True** Sandals should never be worn in the laboratory.

5) **True** Long, loose hair is a fire hazard.

6) **True** You should remove all jewelry before working in the laboratory.

7) **False** Chemical waste should be disposed of down the sink unless the teacher tells you otherwise.

8) **True** Long sleeves should be rolled up before working in the lab.

9) **True** It is a safety violation to leave your lab area dirty.

10) **False** It isn't hazardous to eat or drink in the lab if you've put all of the chemicals at your lab area away.

Suggested Grading Key

10 = A+ (100%)
9 = A
8 = B
7 = C
6 = D
< 6 = F

Quiz: Lab Equipment and Safety

1) Identify the following ten pieces of laboratory equipment (1 point each):

a) _____

b) _____

c) _____

d) _____

e) _____

f) _____

g) _____

h) _____

i) _____

j) _____

2) What is the proper way to mix acid and water? (2 points)

3) Name the pieces of safety equipment in our lab (3 points):

4) Why shouldn't you pour chemical waste down the sink? (2 points)

5) When is it proper to take your goggles off in the laboratory? (2 points)

Quiz Key: Lab Equipment and Safety

1) Identify the following ten pieces of laboratory equipment (1 point each):
For this question, hold up ten pieces of laboratory equipment, one by one. This ensures that the kids are able to identify the lab equipment that you will be using most frequently in the lab.

2) What is the proper way to mix acid and water? (2 points)
Acid should always be added to water to avoid splattering.

3) Name the pieces of safety equipment in our lab (3 points):
All chemistry laboratories should have the following pieces of laboratory equipment: Eyewash, shower, fire extinguisher, fire blanket, first aid kit, acetic acid solution (for neutralizing base burns), sodium bicarbonate solution (for neutralizing acid burns), fume hood. If you don't have these in your classroom, RUN, don't walk, to your administrator and get them immediately! For this question, desperate students will frequently refer to the fire sprinklers as being safety equipment. Point out to them that fire extinguishers are not "equipment" as they are not intended to be operated by the students.

4) Why shouldn't you pour chemical waste down the sink? (3 points)
Chemicals poured down the sink may react with each other. It's also a serious environmental hazard to dispose of chemicals in this way.

5) When is it proper to take your goggles off in the laboratory? (2 points)
Never.

Suggested grading key:

20 = A+ (100%)
18-19 = A
17= B+
16 = B
15 = C+
14 = C
13 = D+
12 = D
<12 = F

Scientific Method Quiz

1) When I was in college I had some problems with an English class I was taking. I wanted to do better in this class, so I needed to figure out a way to improve my grade. Use the six steps of the scientific method to find a way to solve my problem. For the final steps, use your imagination to predict what would happen. Be sure to name the six steps of the scientific method in your answer!

Scoring: *6 points for naming the six steps of the scientific method correctly (1 point per step)*
3 points for putting the steps in the correct order (all or nothing)
6 points for proper use in this scenario (1 point per step)

2) Is the scientific method a good way of solving problems? Explain yourself in at least a paragraph, making sure to fully explain the reasons for your answer. (10 points)

Important scoring information: More points will be given to answers that show you understand the scientific method, regardless of whether or not you believe it's a good way of solving problems. I'm interested in your reasoning, NOT in how much you agree with what I think.

Scientific Method Quiz – Solutions

1) When I was in college I had some problems with an English class I was taking. I wanted to do better in this class, so I needed to figure out a way to improve my grade. Use the six steps of the scientific method to find a way to solve my problem. For the final steps, use your imagination to predict what would happen. Be sure to name the six steps of the scientific method in your answer!

Scoring: *6 points for naming the six steps of the scientific method correctly (1 point per step)*
3 points for putting the steps in the correct order (all or nothing)
6 points for proper use in this scenario (1 point per step)

One point should be given for each of the six steps of the scientific method, with a three point bonus for putting them in order. The correct steps and order are: Purpose, hypothesis, materials, procedure, results, and conclusion.

For the other six points, the students should put a reasonable set of actions for each step of the scientific method. This may be somewhat difficult to grade, as some students will give strange or unusual answers. Give points based on whether or not they are technically correct and not on how likely they are to occur.

Sample answers:

Purpose: I need to improve my English grade
Hypothesis: If I drink more coffee right before the test, my score will improve.
Materials: Coffee cup, coffee, cream, sugar, stirring stick
Procedure:
1) Make a big cup of coffee
2) Add one spoon of sugar and a little splash of cream
3) Stir with the stirring stick
4) Drink coffee
5) Repeat steps 1-4 until the test.
Results: I did poorly on the test because I kept having to leave to use the restroom.
Conclusion: Drinking coffee right before the test is not a good way to achieve higher scores.

2) Is the scientific method a good way of solving problems? Explain yourself in <u>at least</u> a paragraph, making sure to fully explain the reasons for your answer. (10 points)

<u>Important scoring information</u>: More points will be given to answers that show you understand the scientific method, regardless of whether or not you believe it's a good way of solving problems. I'm interested in your reasoning, NOT in how much you agree with what I think.

This problem is more difficult to score than problem #1 because there is more than one correct answer.

Most students will say something along the lines of, "The scientific method is the most marvelous way in the entire world to solve problems!" This answer is fine, but to receive credit there should be justification for this statement. Good reasons include that the scientific method changes only one variable at a time, it requires you to keep good records about your experiments, and it's methodical and rigorous. Other answers may be appropriate – you make the call.

Some students will say things like, "The scientific method is not a very good way of solving problems!" This is also fine, but there should be good justification for making this statement. One compelling argument is that the scientific method isn't realistic and that most discoveries are made intuitively. This answer is hard to refute, as it is correct. Another answer you'll see a lot is that the scientific answer takes too long and requires a lot of writing. This is a much less convincing argument. For all answers, use your best judgement and make sure to keep an open mind if the students disagree with what you think. Remember, the idea is to make sure that they understand the concepts, not that they agree with everything we say.

<u>Suggested Grading Scale</u>

25 = A+
23 – 24 = A
22 = B+
20 – 21 = B
19 = C+
18 = C
17 = D+
15 – 16 = D
< 15 = F

Elements, Compounds, and Mixtures Quiz

For problems 1-6, indicate whether the substance named is an element, a compound, a heterogeneous mixture, or a homogeneous mixture (1 pt. each):

1) hamburger _____

2) sodium chloride (table salt) _____

3) iced tea _____

4) gold bar _____

5) pony _____

6) air _____

Please answer the following questions about elements, compounds, and mixtures (4 points each):

7) Which is easier to separate, a homogeneous or heterogeneous mixture? Explain your answer, giving a specific example.

8) We often talk about separating mixtures. Why don't we ever talk about separating elements or compounds?

9) What is the main difference between an atom and a molecule?

Elements, Compounds, and Mixtures Quiz - Solutions

For problems 1-6, indicate whether the substance named is an element, a compound, a heterogeneous mixture, or a homogeneous mixture (1 pt. each):

1) hamburger **heterogeneous mixture**

2) sodium chloride (table salt) **compound**

3) iced tea **homogeneous mixture**

4) gold bar **element**

5) pony **heterogeneous mixture**

6) air **homogeneous mixture**

Please answer the following questions about elements, compounds, and mixtures (4 points each):

7) Which is easier to separate, a homogeneous or heterogeneous mixture? Explain your answer, giving a specific example.

Heterogeneous mixtures are easier to separate because you can see the different components in the mixture. For example, it is easy to separate a mixture of candies because you can detect the different colors and physically sort them. On the other hand, it's difficult to separate a homogeneous mixture because it's difficult to tell what components are present, or even if it's a mixture at all. An example of this would be salt water. In salt water, you need to boil the water away to separate the water and salt because they are so closely connected.

8) We often talk about separating mixtures. Why don't we ever talk about separating elements or compounds?

Elements and compounds are pure substances – there are no different components to separate. Elements consist of all the same type of atom. Compounds contain different elements, but they're chemically bonded, making them impossible to physically separate.

9) What is the main difference between an atom and a molecule?

Atoms are the simplest units of an element that retain the properties of that element. Molecules are the simplest units of a compound that retain the properties of that compound. Whereas atoms cannot be broken down using chemical methods, compounds can be broken into their component atoms if a chemical change occurs.

Suggested Grading Scale

18 = A+
17 = A
16 = B+
15 = B
14 = C+
13 = C
12 = D+
11 = D
< 11 = F

Scientific Notation, Significant Figures, and Unit Conversions Quiz

Convert the following numbers into scientific notation (1 point each):

1) 9,870 _____

2) 45,000 _____

3) 0.0012 _____

4) 8,900,000,000 _____

Convert the following numbers into standard notation (1 point each):

5) 7.54×10^{4} _____

6) 9.11×10^{-3} _____

7) 8.776×10^{-6} _____

8) 1.42×10^{5} _____

How many significant figures are in the following numbers? (1 point each)

9) 120 _____

10) 0.001010 _____

11) 100.10 _____

12) 2.10×10^{4} _____

Do the following unit conversions. All necessary conversion factors are provided to you in the problem:

13) Convert 376 inches into centimeters. *There are 2.54 centimeters in 1 inch. (3 points)*

14) Convert 0.761 meters into millimeters. *(3 points)*

15) Convert 3.42×10^{3} minutes into hours. *(3 points)*

16) Convert 47 miles into centimeters. *There are 0.61 miles in 1 kilometer. (6 points)*

17) Convert 8.91×10^{-6} years into seconds. *1 year has 365 days. (6 points)*

18) Convert 245^{0} C to Kelvins (3 points)

19) What is the main difference between precision and accuracy? Your answer should give specific examples of each. (6 points)

Scientific Notation, Significant Figures, and Unit Conversions Quiz - Solutions

Convert the following numbers into scientific notation (1 point each):

1) 9,870 **9.87×10^3**

2) 45,000 **4.5×10^4**

3) 0.0012 **1.2×10^{-3}**

4) 8,900,000,000 **8.9×10^9**

Convert the following numbers into standard notation (1 point each):

5) 7.54×10^4 **75,400**

6) 9.11×10^{-3} **0.00911**

7) 8.776×10^{-6} **0.000008776**

8) 1.42×10^5 **142,000**

How many significant figures are in the following numbers? (1 point each)

9) 120 **2**

10) 0.001010 **4**

11) 100.10 **5**

12) 2.10×10^4 **3**

Do the following unit conversions. All necessary conversion factors are provided to you in the problem:

13) Convert 376 inches into centimeters. *There are 2.54 centimeters in 1 inch. (3 points)*
955 centimeters

14) Convert 0.761 meters into millimeters. *(3 points)*
761 millimeters

15) Convert 3.42×10^3 minutes into hours. *(3 points)*
57 hours

16) Convert 47 miles into centimeters. *There are 0.61 miles in 1 kilometer. (6 points)*
7.7×10^6 centimeters, or 7,700,000 centimeters

17) Convert 8.91×10^{-6} years into seconds. *1 year has 365 days. (6 points)*
281 seconds

18) Convert 245^0 C to Kelvins (3 points)
518 K (a common incorrect answer will be –28 K. This is what the answer is if you subtract 273 from the temperature in Celsius rather than adding it)

19) What is the main difference between precision and accuracy? Your answer should give examples of each. (6 points)
Accuracy is a measurement of how close an experimental reading is to the actual answer. For example, I am 178 cm tall. If I used a ruler that said I'm 179 cm tall, that's a reasonably accurate answer.

Precision is a measurement of how repeatable an experimental reading is, and is usually denoted by an increase in the number of significant figures shown in the number. If I find my wife's height to be 168.001 cm tall with three repeated measurements, then the reading is said to be precise.

Accuracy and precision are usually aligned with each other. In other words, accurate readings are usually precise. However, this isn't always true. For example, if my wife is actually 155.000 cm tall, the measurement device in the paragraph above is still very precise (it's very repeatable) but it's not very accurate (close to the true value). Measurements that are precise but not accurate are usually the result of miscalibration.

Suggested Grading Scale

42 = A+
38 – 41 = A
36 – 37 = B+
34 – 35 = B
32 – 33 = C+
30 – 31 = C
28 – 29 = D+
26 – 27 = D
< 26 = F

Periodic Table Quiz

List as many of the main properties of each of the following groups as you can (2 points each):

1) alkali metals:

2) alkaline earth metals:

3) halogens:

4) noble gases:

5) transition metals:

6) metals:

7) metalloids:

8) nonmetals:

9) hydrogen:

For each of the following, give the periodic trend for each of the following as well as a reason for this trend. (5 points each)

<u>Example</u>: Atomic number
Correct answer: It increases as you move across the periodic table and also increases as you move down the periodic table. This is because every element has one more proton than the one before it.

10) electronegativity:

11) atomic radius:

12) ionization energy:

13) What does the word "diatomic" mean? What elements on the periodic table do we associate with the word "diatomic"? (5 points)

Periodic Table Quiz - Solutions

List as many of the main properties of each of the following groups as you can (2 points each):

1) alkali metals: **Form ions with a charge of +1, soft, reactive with water and oxygen, form basic solutions, low density, low electronegativity, low melting and boiling points.** ***(0.5 points each for a maximum of 2 points)***

2) alkaline earth metals: **Form ions with a charge of +2, soft (but less so than the alkali metals), low density (but less so than alkali metals), reactive with water and oxygen (but less so than alkali metals), low electronegativity, low melting and boiling points (but less so than alkali metals).** ***(0.5 points each for a maximum of 2 points)***

3) halogens: **High reactivity (particularly with metals to form compounds with the general formula MX_n and hydrogen to form HX), high electronegativity, diatomic, strong oxidizers, form ions with a –1 charge.** ***(0.5 points each for a maximum of 2 points, though for lower level classes you may wish to give 1 point each for a maximum of two points)***

4) noble gases: **Extremely unreactive.** ***(2 points)***

5) transition metals: **Hard, less reactive than other metals, have more than one possible positive charge, dense, high melting and boiling points.** ***(0.5 points each for a maximum of 2 points)***

6) metals: **malleable, ductile, lustrous, thermal and electrical conductors, form basic oxides, high density, generally solid, form cations.** ***(0.5 points each for a maximum of 2 points)***

7) metalloids: **electrical semiconductors, have properties between those of the metals and nonmetals.** ***(1 point each, though you may want to give 0.5 points each if they specify what properties of metals and nonmetals they have)***

8) nonmetals: **nonlustrous (many are colored), may be solids, liquids, or gases, poor conductors of heat and electricity, form anions, solid nonmetals are brittle, form acidic oxides.** ***(0.5 points each for a maximum of 2 points)***

9) hydrogen: **Can form ions with a +1 (hydronium) or –1 (hydride) charge, diatomic, gas, reacts with the halogens to form HX, extremely flammable.** ***(0.5 points each for a maximum of 2 points)***

For each of the following, give the periodic trend for each of the following as well as a reason for this trend. (5 points each)

10) electronegativity:
- **Increases as you move across the periodic table because the energy of each electron in the sublevel is the same even though the amount of positive charge in the nucleus increases. This causes a higher effective nuclear charge ($Z_{effective}$) that attracts electrons.**
- **Decreases as you move down the periodic table because of the shielding effect (inner electrons cause a decrease in the effective nuclear charge, causing it to attract electrons less well).**

11) atomic radius:
- **Decreases as you move across the periodic table because the energy of each electron in the sublevel is the same even though the amount of positive charge in the nucleus increases. This causes a higher effective nuclear charge ($Z_{effective}$) that causes these electrons to be bound more tightly to the nucleus.**
- **Increases as you move down the periodic table because each sublevel has more energy than the one before it.**

12) ionization energy:
- **Increases as you move across the periodic table because increased nuclear charge causes the electrons to be held more tightly. As a result, it takes more energy to pull them off to ionize the atom.**
- **Decreases as you move down the periodic table because the shielding effect causes outer electrons to be bound less tightly.**

13) What does the word "diatomic" mean? What elements on the periodic table do we associate with the word "diatomic"? (5 points)
"Diatomic" means that elements form molecules consisting of two atoms of that element bound together. The diatomic elements on the periodic table are hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, and iodine. (2.5 points for defining "diatomic", 2.5 points for correctly naming the seven diatomic elements).

<u>Suggested Grading Scale</u>
38 = A+
34.5 – 37 = A
32.5 – 34 = B+
30.5 – 32 = B
28.5 – 30 = C+
27 – 28 = C
25 – 26 = D+
23 – 24 = D
< 23 = F

Atomic Theories Quiz

1) John Dalton discussed an early model of the atom. His model consisted of five basic postulates. List each of these postulates and explain what they mean. No points will be deducted if these postulates are listed in an order different than we learned in class. (3 points each)

- Postulate 1:

- Postulate 2:

- Postulate 3:

- Postulate 4:

- Postulate 5:

2) Which of the postulates above have been disproved? (2 points)

1 **2** **3** **4** **5** (circle as many as are appropriate)

3) Explain Thomson's cathode ray experiment and describe its significance. You may draw a diagram if it will help you to answer this question (10 points).

4) Explain Rutherford's gold foil experiment and describe its significance. You may draw a diagram if it will help you to answer this question (10 points).

5) List the main differences and similarities between the Bohr model of the atom and the quantum mechanical model of the atom. Make sure your answers are complete. (15 points)

Atomic Theories Quiz - Solutions

1) John Dalton discussed an early model of the atom. His model consisted of five basic postulates. List each of these postulates and explain what they mean. No points will be deducted if these postulates are listed in an order different than we learned in class. (3 points each)

- Postulate 1: **All matter is made of indestructible atoms. This means that atoms are as small as matter gets, like tiny unbreakable billiard balls.**

- Postulate 2: **All atoms of an element have identical chemical and physical properties. This means that if you know the properties of one atom of an element you can predict what the properties of all atoms of that element are.**

- Postulate 3: **Atoms of different elements have different chemical and physical properties. This means that the properties of each element define that element, and that no two elements can be identical in how they behave.**

- Postulate 4: **Atoms of different elements always combine in whole-number ratios when they form chemical compounds. This means that all chemical formulas have the general form A_xB_y, where x and y are whole numbers. This is, in effect, the same thing as the law of multiple proportions.**

- Postulate 5: **Atoms are never created or destroyed during chemical reactions. This is the same thing as the law of conservation of mass.**

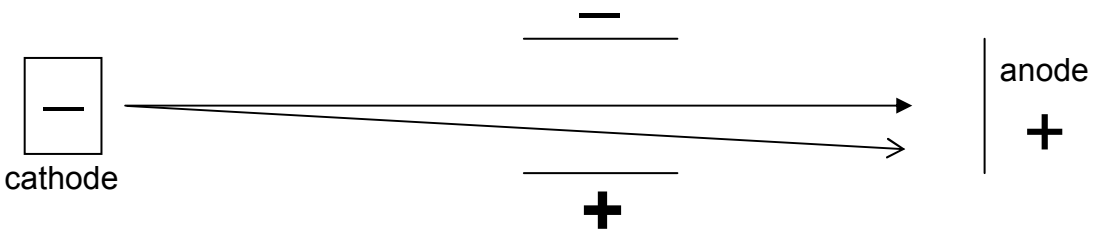
2) Which of the postulates above have been disproved? (2 points)

(1) **2** **3** **4** **5** (circle as many as are appropriate)

Atoms are not indestructible because they can be broken during nuclear reactions. However, it is true that atoms are indestructible during chemical reactions (the making and breaking of bonds).

3) Explain Thomson's cathode ray experiment and describe its significance. You may draw a diagram if it will help you to answer this question (10 points).

Thomson's experiment involved a cathode ray tube, where "cathode rays" traveled across a partially evacuated tube, from the negative electrode (cathode) to the positive electrode (anode). When charged plates were placed to the sides of this beam, they would either attract the cathode ray (if they were positive) or attract the cathode ray (if they were negative). From this experiment, Thomson was able to determine that it had a negative charge. Of course, we now know that cathode rays are the same thing as electrons.



The above diagram shows the Thomson cathode ray apparatus. The arrow with the solid head represents the path of the "cathode rays" in the absence of an external electric field. The open head represents the path when the electric field is applied.

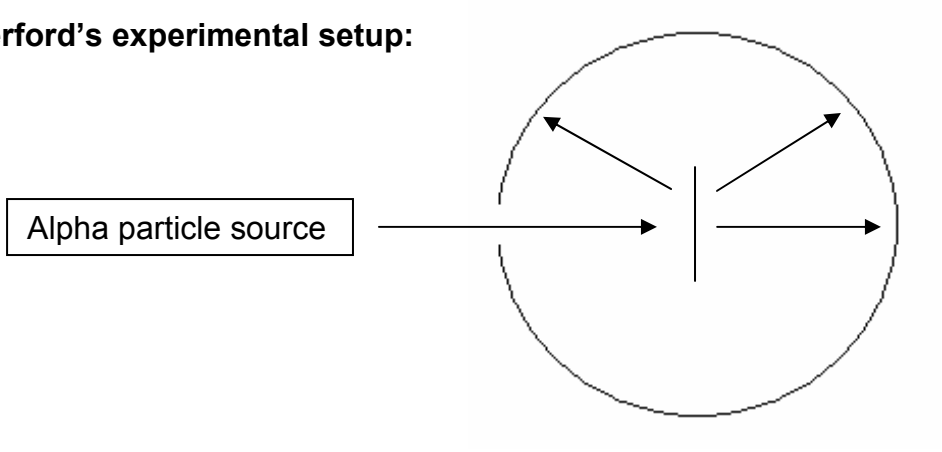
From this experiment, Thomson inferred that atoms are great big balls of positive charge with electrons embedded in it. This model is frequently referred to as the "plum-pudding" model of the atom because the dessert has small bits of plum stuck into a big ball of bread.

4) Explain Rutherford's gold foil experiment and describe its significance. You may draw a diagram if it will help you to answer this question (10 points).

Rutherford shot a beam of alpha particles at a thin piece of gold foil. Because the foil was so thin, most of the positively charge alpha particles passed directly through the foil onto a luminescent screen. However, some of the particles were deflected so they hit different locations on the screen. Rutherford interpreted this result to mean that most of the space in an atom consists of empty space (explaining why most of the particles passed directly through the foil) but that there is a central nucleus of the atom where all of the positive charge is located (explaining why some of the positively charged alpha particles were deflected). He hypothesized that the electrons traveled around the nucleus at a distance.

Diagram of Rutherford's experiment on the next page.

Rutherford's experimental setup:



During the gold foil experiment, alpha particles were focused on a very thin piece of gold foil surrounded by a phosphorescent screen. He observed that most of the alpha particles passed through the foil undeflected, but some were slightly deflected and others bounced back.

5) List the main differences and similarities between the Bohr model of the atom and the quantum mechanical model of the atom. Make sure your answers are complete. (15 points)

Similarities: 3

- **Electrons are located outside the nucleus in orbitals.**
- **The energy levels in an atom are quantized.**
- **Orbitals close to the nucleus have lower energies than orbitals farther away.**

Differences:

- **The Bohr atom has electrons in spherical orbits around the nucleus and the quantum mechanical model has electrons in regions of space with varying shapes and sizes.**
- **The energy of the orbitals in the Bohr atom is based mainly on the distance from the nucleus, while the energy and location of the orbitals in the quantum model is based on the wavefunction.**
- **The quantum model has four quantum numbers, the Bohr model does not.**
- **The quantum model has the Pauli Exclusion principle, Hund's rule, and the Aufbau principle.**

Suggested Grading Scale

52 = A+
47 – 51 = A
45 – 46 = B+
42 – 44 = B
39 – 41 = C+
37 – 38 = C
34 – 36 = D+
31 – 33 = D
< 31 = F

Atom Quiz

1) Sketch a simple diagram of the ^{9}Be atom and label the following parts: orbitals, nucleus, protons, neutrons, electrons (10 points)

2) Fill out the following chart. Round the atomic masses to the nearest whole number. (0.5 point per blank)

Atomic symbol	Atomic mass	Atomic number	Number of protons	Number of neutrons	Number of electrons
Li					
Si					
Mn					
I					
Ra					
Bk					

3) Write the electron configurations of the following elements: (2 points each)

a) nitrogen _____

b) potassium _____

c) silver _____

d) plutonium _____

4) A sample of silver has the following isotopic abundances:

Isotope	Isotopic mass (amu)	Isotopic abundance (%)
^{107}Ag	106.905	50.958
^{109}Ag	108.905	49.042

What is the average atomic mass of this sample of silver? Note: It may not be the same as the mass given on the periodic table! (8 points)

Atom Quiz – Solutions

1) Sketch a simple diagram of the ^{9}Be atom and label the following parts: orbitals, nucleus, protons, neutrons, electrons (10 points)
To receive full credit, this diagram should show each of the following (two points each):
- **Two orbitals around the nucleus. The orbital nearest to the nucleus should be labeled "1s" and the other should be labeled "2s".**
- **Four electrons – Two in the 1s orbital and two in the 2s orbital. The electrons should be labeled or have the symbol "e^-".**
- **The nucleus should be labeled.**
- **The nucleus should contain four protons, each labeled either with a plus sign or as "p^+".**
- **The nucleus should contain five neutrons, each labeled either with a zero or as "n^0".**

2) Fill out the following chart. Round the atomic masses to the nearest whole number. (0.5 point per blank)

Atomic symbol	Atomic mass	Atomic number	Number of protons	Number of neutrons	Number of electrons
Li	**7**	**3**	**3**	**4**	**3**
Si	**28**	**14**	**14**	**14**	**14**
Mn	**55**	**25**	**25**	**30**	**25**
I	**127**	**53**	**53**	**74**	**53**
Ra	**226**	**88**	**88**	**138**	**88**
Bk	**247**	**97**	**97**	**150**	**97**

3) Write the electron configurations of the following elements: (2 points each)

a) nitrogen **$1s^2 2s^2 2p^3$ OR [He] $2s^2 2p^3$**

b) potassium **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ OR [Ar] $4s^1$**

c) silver **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^9$ OR [Kr] $5s^2 4d^9$**

d) plutonium
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 5f^6$
OR
[Rn] $7s^2 5f^6$

4) A sample of silver has the following isotopic abundances:

Isotope	Isotopic mass (amu)	Isotopic abundance (%)
^{107}Ag	106.905	50.958
^{109}Ag	108.905	49.042

What is the average atomic mass of this sample of silver? Note: It may not be the same as the mass given on the periodic table! (8 points)
To solve this problem, they will need to show the following equation:

Isotopic mass = (Abundance of isotope 1)(Mass of isotope 1) +
(Abundance of isotope 2)(Mass of isotope 2)

Which in this case is:
(0.50958)(106.905 amu) + (0.49042)(108.905 amu) =
54.477 amu + 53.409 amu = 107.886 amu

This answer is slightly different from the value of 107.868 amu on the periodic table.

Note: Slight differences in isotopic abundances may exist in some elements for a variety of reasons and can be useful in determining the date of very old artifacts.

Suggested Grading Scale
41 = A+
37 – 40.5 = A
35 – 36.5 = B+
33 – 34.5 = B
31 – 32.5 = C+
29 – 30.5 = C
27 – 28.5 = D+
24.5 – 26.5 = D
< 24.5 = F

Ionic Compounds Overview Quiz

1) Explain what happens when a neutral atom of sodium combines with a neutral atom of fluorine to become a molecule of sodium fluoride. Make sure your answer is *complete*. (8 points)

2) What is the octet rule and why is it important for atoms forming ionic bonds? (6 points)

3) What are the four main properties of ionic compounds? (8 points)

-
-
-
-

4) Why do ionic compounds have each of the four general properties you listed in problem three? You should explain how the method of bonding causes each of the properties you listed. (8 points)

Ionic Compounds Overview Quiz – Solutions

1) Explain what happens when a neutral atom of sodium combines with a neutral atom of fluorine to become a molecule of sodium fluoride. Make sure your answer is *complete*. (8 points)

To get this answer correct, each of the following steps should be listed (2 points each):

- **Sodium wants to lose one electron so it will have the same electron configuration as neon.**
- **Fluorine wants to gain one electron so it will have the same electron configuration as neon.**
- **As a result, sodium will give one of its electrons to fluorine, giving sodium a +1 charge and fluorine a –1 charge.**
- **Because opposite charges attract one another, the positively charged sodium ion and negatively charged fluoride ion stick to one another to form sodium fluoride.**

2) What is the octet rule and why is it important for atoms forming ionic bonds? (6 points)

The octet rules states that all atoms tend to react such that they end up with eight electrons in its outermost valence shell. (An easier way for your students to remember this: "All atoms want to be like the nearest noble gas"). This is important for atoms forming ionic bonds because atoms wanting to gain electrons will pull electrons from atoms wanting to lose electrons, resulting in the formation of oppositely charged ions. When oppositely charged ions are formed near one another, the ions stick together to form ionic compounds.

3) What are the four main properties of ionic compounds? (8 points)

- **Ionic compounds are hard and brittle**
- **Ionic compounds have high melting and boiling points**
- **Ionic compounds form crystal lattices**
- **Ionic compounds conduct electricity when dissolved in water**

4) Essay question: What affect does the type of bonding present in ionic compounds have on the properties of ionic compounds? Pick three of the four properties you gave in problem three and explain how the nature of ionic bonding is responsible for the presence of these properties. (15 points)

Many of the properties of ionic compounds stem from the strong bonding interactions between cations and anions.

This strong bonding makes ionic compounds hard and brittle because it takes a very large amount of force to move ions in relation to one another. In fact, it takes so much force that the applied force causes the entire crystal to shatter before it will dent or bend. Because the cations and anions are arranged in regular patterns, crystals tend to break along planes. (5 points)

High melting and boiling point can also be attributed to these strong ionic bonds. When you melt or boil a substance, this causes the particles in the substance to move freely with respect to one another. In ionic compounds it requires a very large amount of heat to cause this free movement because cations and anions are so strongly attracted that they spontaneously tend to stick together. (5 points)

Ionic compounds form crystals because crystals are a very efficient way of packing together ions such that the attraction between oppositely charged ions is maximized. For example, if you look at a cubic lattice you can see that each cation is in direct contact with six anions, and vice-versa. (5 points)

The fact that ionic compounds are electrolytes in water cannot be easily explained by the interactions between cations and anions. As a result, they should not have picked this property from problem three to answer this essay.

<u>Suggested Grading Scale</u>

37 = A+
34 – 36 = A
32 – 33 = B+
30 – 31 = B
28 – 29 = C+
26 – 27 = C
24 – 25 = D+
22 – 23 = D
< 22 = F

Naming Ionic Compounds Quiz

Give the formulas for the following compounds (1 point each):

1) potassium carbonate _____

2) magnesium sulfide _____

3) nickel (III) oxide _____

4) aluminum phosphide _____

5) sodium nitrite _____

6) manganese (IV) sulfate _____

7) chromium (VI) sulfite _____

8) calcium phosphate _____

9) chromium (II) phosphide _____

10) lithium permanganate _____

11) titanium (III) acetate _____

12) iron (III) selenide _____

13) zinc hydroxide _____

14) copper (I) carbonate _____

15) beryllium bromide _____

16) lead (IV) bicarbonate _____

Given the following formulas, name the ionic compound (1 point each):

17) $FeSO_3$ _____

18) CrF_3 _____

19) $Mn(OH)_7$ _____

20) $Ti_3(PO_4)_2$ _____

21) $(NH_4)_3As$ _____

22) $NiCO_3$ _____

23) $Mn(NO_2)_3$ _____

24) K_2S _____

25) TiN _____

26) $CaSO_4$ _____

27) CoP _____

28) $Mg(OH)_2$ _____

29) V_2O_3 _____

30) $Zn(NO_3)_2$ _____

31) $Ga(HCO_3)_3$ _____

32) $Ag_2C_2O_4$ _____

Naming Ionic Compounds Quiz - Solutions

Give the formulas for the following compounds (1 point each):

1)	potassium carbonate	**K_2CO_3**
2)	magnesium sulfide	**MgS**
3)	nickel (III) oxide	**Ni_2O_3**
4)	aluminum phosphide	**AlP**
5)	sodium nitrite	**$NaNO_2$**
6)	manganese (IV) sulfate	**$Mn(SO_4)_2$**
7)	chromium (VI) sulfite	**$Cr(SO_3)_3$**
8)	calcium phosphate	**$Ca_3(PO_4)_2$**
9)	chromium (II) phosphide	**Cr_3P_2**
10)	lithium permanganate	**$LiMnO_4$**
11)	titanium (III) acetate	**$Ti(C_2H_3O_2)_3$ OR $Ti(CH_3COO)_3$**
12)	iron (III) selenide	**Fe_2Se_3**
13)	zinc hydroxide	**$Zn(OH)_2$**
14)	copper (I) carbonate	**Cu_2CO_3**
15)	beryllium bromide	**$BeBr_2$**
16)	lead (IV) bicarbonate	**$Pb(HCO_3)_4$**

Given the following formulas, name the ionic compound (1 point each):

17) $FeSO_3$ **iron (II) sulfite**

18) CrF_3 **chromium (III) fluoride**

19) $Mn(OH)_7$ **manganese (VII) hydroxide**

20) $Ti_3(PO_4)_2$ **titanium (II) phosphate**

21) $(NH_4)_3As$ **ammonium arsenide**

22) $NiCO_3$ **nickel (II) carbonate**

23) $Mn(NO_2)_3$ **manganese (III) nitrite**

24) K_2S **potassium sulfide**

25) TiN **titanium (III) nitride**

26) $CaSO_4$ **calcium sulfate**

27) CoP **cobalt (III) phosphide**

28) $Mg(OH)_2$ **magnesium hydroxide**

29) V_2O_3 **vanadium (III) oxide**

30) $Zn(NO_3)_2$ **zinc nitrate**

31) $Ga(HCO_3)_3$ **gallium bicarbonate**

32) $Ag_2C_2O_4$ **silver oxalate**

Suggested Grading Scale

32 = A+
29 – 31 = A
28 = B+
26 – 27 = B
25 = C+
23 – 24 = C
21 – 22 = D+
20 = D
< 20 = F

Molecular Calculations Quiz

1) How many grams of copper (II) sulfate are there in 2.50 moles? (3 points)

2) How many moles of silver acetate are there in 4.90×10^{22} molecules? (3 points)

3) How many grams of lithium oxide are there in 7.40×10^{24} molecules? (5 points)

4) How many molecules are there in 223 grams of iron (III) iodide? (5 points)

5) When 1,1-dimethylcyclobutane undergoes an elemental analysis, it is found to contain 85.7% carbon and 14.3% hydrogen (by mass). Based on this information, what is the empirical formula of 1,1-dimethylcyclobutane? (6 points)

6) After other tests were done, the molecular mass of 1,1-dimethylcyclobutane was found to be 84 grams/mole. Based on this information, what is the molecular formula of 1,1-dimethylcyclobutane? (6 points)

7) An unknown compound was analyzed and found to have an elemental composition of 65.4% carbon, 5.5% hydrogen, and 29.1% oxygen. Based on the information in the following chart, what is the name of the unknown compound? (10 points)

Name of compound	**Molecular Formula**
Acetone	C_3H_6O
Oxalic acid	$C_2H_2O_4$
4-hydroxyphenol	$C_6H_6O_2$

Molecular Calculations Quiz – Solutions

1) How many grams of copper (II) sulfate are there in 2.50 moles? (3 points)
399 grams (multiply the molecular mass of copper (II) sulfate, 159.6 grams, by the number of moles)

2) How many moles of silver acetate are there in 4.90×10^{22} molecules? (3 points)
0.0814 moles (divide 4.90×10^{22} by 6.02×10^{23}; when converting between molecules and moles, the identity of the compound being used is not important)

3) How many grams of lithium oxide are there in 7.40×10^{24} molecules? (5 points)
366 grams (convert molecules to moles by dividing my 6.02×10^{23}, then multiply by the molar mass of lithium oxide)

4) How many molecules are there in 223 grams of iron (III) iodide? (5 points)
3.21×10^{23} molecules (convert grams to moles by dividing by the molar mass, then multiply by Avogadro's number)

5) When 1,1-dimethylcyclobutane undergoes an elemental analysis, it is found to contain 85.7% carbon and 14.3% hydrogen (by mass). Based on this information, what is the empirical formula of 1,1-dimethylcyclobutane? (6 points)
CH_2 (To solve, assume you have 100. grams of the compound – this essentially changes the percent values to grams. Next, divide each of these masses by the atomic masses of each element. This results in an answer of 7.14 moles of carbon and 14.3 moles of hydrogen. Next, divide each value by the smallest, in this case, 7.14. This causes the number of carbons to equal one and the number of hydrogens to equal ~2. Using these numbers, the empirical formula is CH_2.)

6) After other tests were done, the molecular mass of 1,1-dimethylcyclobutane was found to be 84 grams/mole. Based on this information, what is the molecular formula of 1,1-dimethylcyclobutane? (6 points)
C_6H_{12} (Divide the actual molecular mass of the compound by the mass of the empirical formula, 14 grams/mole. This yields the number six. When the subscripts in the empirical formula are each multiplied by this number, you get the molecular formula.)

7) An unknown compound was analyzed and found to have an elemental composition of 65.4% carbon, 5.5% hydrogen, and 29.1% oxygen. Based on the information in the following chart, what is the name of the unknown compound? (10 points)

Name of compound	Molecular Formula
Acetone	C_3H_6O
Oxalic acid	$C_2H_2O_4$
4-hydroxyphenol	$C_6H_6O_2$

4-hydroxyphenol (Solving this problem in the same manner as question five, you find that the empirical formula of the unknown is C_3H_3O. Of the three compounds listed, the only compound that has that empirical formula is 4-hydroxyphenol.)

Suggested Grading Scale

38 = A+
35 – 37 = A
33 – 34 = B+
31 – 32 = B
29 = C+
27 – 28 = C
25 – 26 = D+
23 – 24 = D
< 23 = F

Covalent Compounds Overview Quiz

1) Explain what happens when two neutral atoms of fluorine combine to form a molecule of F_2. Make sure your answer is *complete*. (6 points)

2) When ionic compounds are formed, electrons are transferred from one atom to another resulting in the formation of cations and anions that stick to each other. Explain why doesn't this transfer of electrons doesn't take place when covalent compounds are formed. (6 points)

3) Many covalent compounds have a "squishy" texture. Explain this property in terms of how bonding occurs in covalent compounds. (6 points)

4) Describe each of the major intermolecular forces that are important for covalent compounds and explain why they occur. You should list them in order of increasing strength, giving examples of compounds that experience these forces. (18 points)

Covalent Compounds Overview Quiz – Solutions

1) Explain what happens when two neutral atoms of fluorine combine to form a molecule of F_2. Make sure your answer is *complete*. (6 points)

Give two points for each of the following steps:

- **Both atoms of fluorine need to gain one electron to become like the nearest noble gas and obey the octet rule.**
- **Because both atoms have identical electronegativities, neither one can pull an electron away from the other.**
- **As a result, the atoms will need to share electrons to get their full octet, resulting in a covalent bond.**

2) When ionic compounds are formed, electrons are transferred from one atom to another resulting in the formation of cations and anions that stick to each other. Explain why doesn't this transfer of electrons doesn't take place when covalent compounds are formed. (6 points)

In ionic compounds, electrons are transferred from one atom to the other because one atom has a much higher electronegativity than the other does. In covalent compounds, the electronegativity difference between the atoms is very small. As a result, neither atom will accept or give up electrons. For both atoms to fill their octets, they must share the electrons.

3) Many covalent compounds have a "squishy" texture. Explain this property in terms of how bonding occurs in covalent compounds. (6 points)

Recall that ionic compounds are hard and brittle because every ion has strong interactions with adjacent counterions. In covalent compounds each molecule has only very weak intermolecular interactions with adjacent molecules. As a result, covalent molecules can easily slide around each other.

As an analogy, think of Lego™ building blocks. These are like ionic compounds because there are very strong interactions holding every block to the ones around it. Covalent compounds, on the other hand, are more like those rooms full of plastic balls that you occasionally see at fast food restaurants. Each half of every ball is held tightly to the other half but the balls have very little interaction with one another.

4) Describe each of the major intermolecular forces that are important for covalent compounds and explain why they occur. You should list them in order of increasing strength, giving examples of compounds that experience these forces. (18 points)

- **London dispersion forces are very weak attractions most important for nonpolar molecules or noble gases. Occasionally, the electrons in a nonpolar molecule will be unequally distributed, causing an instantaneous and very small dipole in the molecule. This, in turn, induces a very small dipole in a neighboring molecule. Because both molecules are very slightly polar, they attract one another. It should be noted, however, that this interaction is very short-lived and very weak.**
- **Dipole-dipole forces occur when two polar molecules interact with one another. When two molecules are polar, they align themselves such that the positive side of one molecule sticks to the negative side of the other. This force is stronger than London dispersion forces because the dipoles involved are permanent and significantly stronger than accidental dipoles. Dipole-dipole forces are significant for alkyl halides (R-X), hydrohalic acids (H-X), and other molecules containing the halogens.**
- **Hydrogen bonding occurs when a hydrogen atom bonded to an electronegative atom is attracted to the lone pair electrons on an electronegative atom on a different molecule. This is a very strong interaction that can last for a significant period of time, particularly in solids. The most important example of a molecule that experiences hydrogen bonding is water. However, amines, alcohols, carboxylic acids, ethers, and other related molecules all experience hydrogen bonding.**

Suggested Grading Scale

36 = A+
33 – 35 = A
31 – 32 = B+
29 – 30 = B
28 = C+
26 – 27 = C
24 – 25 = D+
22 – 23 = D
< 22 = F

Lewis Structures and VSEPR Quiz

1) Name the following covalent compounds (1 point each):

   a) CS_2 _____

   b) NH_3 _____

   c) PBr_5 _____

   d) N_2O_3 _____

   e) SF_6 _____

   f) P_4 _____

2) Give the formulas of the following covalent compounds (1 point each):

   a) methane _____

   b) nitrogen _____

   c) boron trichloride _____

   d) bromine monoxide _____

   e) tetrasulfur tetranitride _____

   f) iodine pentafluoride _____

3) Explain why carbon tetrachloride has a tetrahedral shape rather than a square planar (all atoms arranged like a plus sign) shape. (5 points)

4) Explain why the bonds in carbon dioxide are stronger and shorter than the bonds in carbon tetrachloride. (5 points)

5) Fill in the following chart: (2 points for each Lewis structure, one point for each of the other blanks)

Formula	Lewis structure	Shape	Bond angle
F_2O			
PBr_3			
CO_2			
BH_3			

Lewis Structures and VSEPR Quiz - Solutions

1) Name the following covalent compounds (1 point each):

   a) CS_2 **carbon disulfide**

   b) NH_3 **ammonia**

   c) PBr_5 **phosphorus pentabromide**

   d) N_2O_3 **dinitrogen trioxide**

   e) SF_6 **sulfur hexafluoride**

   f) P_4 **phosphorus**

2) Give the formulas of the following covalent compounds (1 point each):

   a) methane **CH_4**

   b) nitrogen **N_2**

   c) boron trichloride **BCl_3**

   d) bromine monoxide **BrO**

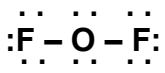
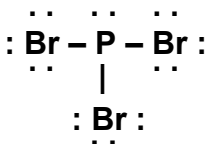
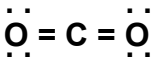
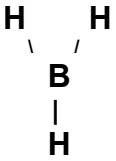
   e) tetrasulfur tetranitride **S_4N_4**

   f) iodine pentafluoride **IF_5**

3) Explain why carbon tetrachloride has a tetrahedral shape rather than a square planar (all atoms arranged like a plus sign) shape. (5 points)
VSEPR theory states that atoms arrange themselves so all substituents are as far away from one another as possible. A tetrahedral shape results in a bond angle of 109.5^0, which is greater than the 90^0 bond angle in a square planar molecule. As a result, carbon tetrachloride has a tetrahedral geometry.

4) Explain why the bonds in carbon dioxide are stronger and shorter than the bonds in carbon tetrachloride. (5 points)
Carbon dioxide has double bonds and carbon tetrachloride has single bonds. Multiple bonds are harder to break and shorter than single bonds because there is more orbital overlap between the atoms involved in the bonding.

5) Fill in the following chart: (2 points for each Lewis structure, one point for each of the other blanks)

Formula	Lewis structure	Shape	Bond angle
F_2O		**bent**	**104.5^0**
PBr_3		**trigonal pyramidal**	**107.5^0**
CO_2		**linear**	**180^0**
BH_3		**trigonal planar**	**120^0**

<u>Suggested Grading Scale</u>

38 = A+
35 – 37 = A
33 – 34 = B+
31 – 32 = B
29 – 30 = C+
27 – 28 = C
25 – 26 = D+
23 – 24 = D
< 23 = F

Compound Naming Quiz

Name the following chemical compounds: (1 point each)

1) $LiCl$ _____

2) KNO_3 _____

3) PBr_5 _____

4) SF_6 _____

5) Fe_2O_3 _____

6) N_2O_3 _____

7) $CuOH$ _____

8) CF_4 _____

9) $Al(NO_2)_3$ _____

10) $MgSO_4$ _____

11) Se_2Br_2 _____

12) MnS_2 _____

13) S_8 _____

14) $Ti_2(CO_3)_3$ _____

15) $AgC_2H_3O_2$ _____

16) SF_6 _____

17) $Cr(PO_4)_2$ _____

18) SiO _____

19) Na_3P _____

20) $FeSO_3$ _____

Write the formulas for the following compounds: (1 point each)

21) beryllium cyanide _____

22) methane _____

23) cobalt (III) iodide _____

24) silver nitrate _____

25) potassium permanganate _____

26) nitrogen _____

27) carbon disulfide _____

28) lithium phosphate _____

29) iron (III) acetate _____

30) copper (II) chloride _____

31) sulfur dibromide _____

32) diselenium dichloride _____

33) vanadium (III) oxide _____

34) calcium hydroxide _____

35) manganese (VI) selenide _____

36) phosphorus trifluoride _____

37) silicon carbide _____

38) zinc sulfite _____

39) nitrogen trioxide _____

40) carbon tetrachloride _____

Compound Naming Quiz – Solutions

Name the following chemical compounds: (1 point each)

1) $LiCl$ **lithium chloride**
2) KNO_3 **potassium nitrate**
3) PBr_5 **phosphorus pentabromide**
4) SF_6 **sulfur hexafluoride**
5) Fe_2O_3 **iron (III) oxide**
6) N_2O_3 **dinitrogen trioxide**
7) $CuOH$ **copper (I) hydroxide**
8) CF_4 **carbon tetrafluoride**
9) $Al(NO_2)_3$ **aluminum nitrite**
10) $MgSO_4$ **magnesium sulfate**
11) Se_2Br_2 **diselenium dibromide**
12) MnS_2 **manganese (IV) sulfide**
13) S_8 **sulfur**
14) $Ti_2(CO_3)_3$ **titanium (III) carbonate**
15) $AgC_2H_3O_2$ **silver acetate**
16) SeF_6 **selenium hexafluoride**
17) $Cr(PO_4)_2$ **chromium (VI) phosphate**
18) SiO **silicon monoxide**
19) Na_3P **sodium phosphide**
20) $FeSO_3$ **iron (II) sulfite**

Write the formulas for the following compounds: (1 point each)

21) beryllium cyanide **$Be(CN)_2$**
22) methane **CH_4**
23) cobalt (III) iodide **CoI_3**
24) silver nitrate **$AgNO_3$**
25) potassium permanganate **$KMnO_4$**

26) nitrogen **N_2**

27) carbon disulfide **CS_2**

28) lithium phosphate **Li_3PO_4**

29) iron (III) acetate **$Fe(C_2H_3O_2)_3$**

30) copper (II) chloride **$CuCl_2$**

31) sulfur dibromide **SBr_2**

32) diselenium dichloride **Se_2Cl_2**

33) vanadium (III) oxide **V_2O_3**

34) calcium hydroxide **$Ca(OH)_2$**

35) manganese (VI) selenide **$MnSe_3$**

36) phosphorus trifluoride **PF_3**

37) silicon carbide **SiC**

38) zinc sulfite **$ZnSO_3$**

39) nitrogen trioxide **NO_3**

40) carbon tetrachloride **CCl_4**

Suggested Grading Scale

40 = A+
36 – 39 = A
34 – 35 = B+
32 – 33 = B
30 – 31 = C+
28 – 29 = C
26 – 27 = D+
24 – 25 = D
< 24 = F

Chemical Equations Quiz

1) Balance the following equations: (1 point each)

___ $LiCl$ + ___ K_2O → ___ Li_2O + ___ KCl

___ KNO_3 + ___ Fe_2O_3 → ___ K_2O + ___ $Fe(NO_3)_3$

___ $CuOH$ + ___ $Al(NO_2)_3$ → ___ $CuNO_2$ + ___ $Al(OH)_3$

___ $NaHCO_3$ → ___ Na_2CO_3 + ___ H_2O + ___ CO_2

___ $Pb(OH)_2$ + ___ $Cr(CO_3)_3$ → ___ $PbCO_3$ + ___ $Cr(OH)_6$

___ C_4H_8 + ___ O_2 → ___ CO_2 + ___ H_2O

___ $Ti_2(CO_3)_3$ + ___ $AgC_2H_3O_2$ → ___ $Ti(C_2H_3O_2)_3$ + ___ Ag_2CO_3

___ S_8 + ___ F_2 → ___ SF_6

___ $MgSO_4$ + ___ MnS_3 → ___ MgS + ___ $Mn(SO_4)_3$

___ $Be(CN)_2$ + ___ $(NH_4)_3P$ → ___ Be_3P_2 + ___ NH_4CN

___ CoI_3 + ___ $KMnO_4$ → ___ $Co(MnO_4)_3$ + ___ KI

___ $CuCl_2$ + ___ V_2O_3 → ___ CuO + ___ VCl_3

___ Ag + ___ $FePO_4$ → ___ Ag_3PO_4 + ___ Fe

___ $Cr_2(CO_3)_3$ + ___ $Ca(OH)_2$ → ___ $Cr(OH)_3$ + ___ $CaCO_3$

___ $NiSO_4$ + ___ $Ca(NO_3)_2$ → ___ $CaSO_4$ + ___ $Ni(NO_3)_2$

2) Write equations for the following chemical reactions: (3 points each)

- When copper wire reacts with an aqueous solution of silver nitrate, silver crystals and aqueous copper (I) nitrate are formed.

- When ethane gas (C_2H_6) is burned in the presence of oxygen, carbon dioxide gas and water vapor are formed.

- When calcium hydroxide pellets react with hydrogen chloride gas, calcium chloride powder and liquid water are formed.

- When calcium carbonate powder is heated to 1200^0 C, calcium oxide powder and carbon dioxide gas are formed.

- When nitrogen gas and oxygen gas react, they form nitrogen trioxide gas.

Chemical Equations Quiz – Solutions

1) Balance the following equations: (1 point each)

2 $LiCl + \mathbf{1}\ K_2O \rightarrow \mathbf{1}\ Li_2O + \mathbf{2}\ KCl$

6 $KNO_3 + \mathbf{1}\ Fe_2O_3 \rightarrow \mathbf{3}\ K_2O + \mathbf{2}\ Fe(NO_3)_3$

3 $CuOH + \mathbf{1}\ Al(NO_2)_3 \rightarrow \mathbf{3}\ CuNO_2 + \mathbf{1}\ Al(OH)_3$

2 $NaHCO_3 \rightarrow \mathbf{1}\ Na_2CO_3 + \mathbf{1}\ H_2O + \mathbf{1}\ CO_2$

3 $Pb(OH)_2 + \mathbf{1}\ Cr(CO_3)_3 \rightarrow \mathbf{3}\ PbCO_3 + \mathbf{1}\ Cr(OH)_6$

1 $C_4H_8 + \mathbf{6}\ O_2 \rightarrow \mathbf{4}\ CO_2 + \mathbf{4}\ H_2O$

1 $Ti_2(CO_3)_3 + \mathbf{6}\ AgC_2H_3O_2 \rightarrow \mathbf{2}\ Ti(C_2H_3O_2)_3 + \mathbf{3}\ Ag_2CO_3$

1 $S_8 + \mathbf{24}\ F_2 \rightarrow \mathbf{8}\ SF_6$

3 $MgSO_4 + \mathbf{1}\ MnS_3 \rightarrow \mathbf{3}\ MgS + \mathbf{1}\ Mn(SO_4)_3$

3 $Be(CN)_2 + \mathbf{2}\ (NH_4)_3P \rightarrow \mathbf{1}\ Be_3P_2 + \mathbf{6}\ NH_4CN$

1 $CoI_3 + \mathbf{3}\ KMnO_4 \rightarrow \mathbf{1}\ Co(MnO_4)_3 + \mathbf{3}\ KI$

3 $CuCl_2 + \mathbf{1}\ V_2O_3 \rightarrow \mathbf{3}\ CuO + \mathbf{2}\ VCl_3$

3 $Ag + \mathbf{1}\ FePO_4 \rightarrow \mathbf{1}\ Ag_3PO_4 + \mathbf{1}\ Fe$

1 $Cr_2(CO_3)_3 + \mathbf{3}\ Ca(OH)_2 \rightarrow \mathbf{2}\ Cr(OH)_3 + \mathbf{3}\ CaCO_3$

1 $NiSO_4 + \mathbf{1}\ Ca(NO_3)_2 \rightarrow \mathbf{1}\ CaSO_4 + \mathbf{1}\ Ni(NO_3)_2$

2) Write equations for the following chemical reactions: (3 points each)

Give students one point for writing the reagents correctly, one point for the correct coefficients, and one point for using the correct symbols (aq, l, Δ, etc.)

- When copper wire reacts with an aqueous solution of silver nitrate, silver crystals and aqueous copper (I) nitrate are formed.

$$1\ Cu_{(s)} + 1\ AgNO_{3(aq)} \rightarrow 1\ Ag_{(s)} + 1\ CuNO_{3(aq)}$$

- When ethane gas (C_2H_6) is burned in the presence of oxygen, carbon dioxide gas and water vapor are formed.

$$2\ C_2H_{6(g)} + 7\ O_{2(g)} \xrightarrow{\Delta} 4\ CO_{2(g)} + 6\ H_2O_{(g)}$$

- When calcium hydroxide pellets react with hydrogen chloride gas, calcium chloride powder and liquid water are formed.

$$1\ Ca(OH)_{2(s)} + 2\ HCl_{(g)} \rightarrow 1\ CaCl_{2(s)} + 1\ H_2O_{(l)}$$

- When calcium carbonate powder is heated to 1200^0 C, calcium oxide powder and carbon dioxide gas are formed.

$$1\ CaCO_{3(g)} \xrightarrow{1200^\circ C} 1\ CaO_{(s)} + 1\ CO_{2(g)}$$

- When nitrogen gas and oxygen gas react, they form nitrogen trioxide gas.

$$N_{2(g)} + 3\ O_{2(g)} \rightarrow 2\ NO_{3(g)}$$

Suggested Grading Scale

30 = A+
27 – 29 = A
26 = B+
24 – 25 = B
23 = C+
21 – 22 = C
20 = D+
18 – 19 = D
< 18 = F

Types of Reactions Quiz

For questions 1 – 8, balance the equation and indicate what type of reaction is taking place. (1 point for correctly balancing each equation, 1 point for correctly identifying each type of reaction.)

1) ____ H_3PO_4 + ____ NaOH → ____ H_2O + ____ Na_3PO_4

Type of reaction: _____

2) ____ C_4H_{10} + ____ O_2 → ____ H_2O + ____ CO_2

Type of reaction: _____

3) ____ $Fe(OH)_2$ + ____ NaCl → ____ $FeCl_2$ + ____ NaOH

Type of reaction: _____

4) ____ Pb + ____ NO_3 → ____ $Pb(NO_2)_4$ + ____ O_2

Type of reaction: _____

5) ____ SO_3 → ____ S_8 + ____ O_2

Type of reaction: _____

6) ____ Ca + ____ H_2O → ____ $Ca(OH)_2$ + ____ H_2

Type of reaction: _____

7) ____ H_2O + ____ SO_3 → ____ H_2SO_4

Type of reaction: _____

8) ____ $MgSO_4$ → ____ MgO + ____ SO_3

Type of reaction: _____

For questions 9-15, predict the products of the reaction and identify the type of reaction taking place. (1 point for correctly predicting the products, 1 point for balancing each equation, 1 point for identifying the type of reaction)

9) ____ C_3H_6 + ____ O_2 →

Type of reaction: _____

10) ____ Cu + ____ $Pb(NO_3)_2$ →

Type of reaction: _____

11) ____ H_2SO_4 + ____ KOH →

Type of reaction: _____

12) ____ $GaBr_3$ + ____ CoF_3 →

Type of reaction: _____

13) ____ $Ti(OH)_3$+ ____ HNO_3 →

Type of reaction: _____

14) ____ Li + ____ I_2 →

Type of reaction: _____

15) ____ $FeSO_3$ + ____ VS_2 →

Type of reaction: _____

Types of Reactions Quiz - Solutions

For questions 1 – 8, balance the equation and indicate what type of reaction is taking place. (1 point for correctly balancing each equation, 1 point for correctly identifying each type of reaction.)

1) **1** H_3PO_4 + **3** NaOH → **3** H_2O + **1** Na_3PO_4

Type of reaction: **acid-base**

2) **2** C_4H_{10} + **13** O_2 → **10** H_2O + **8** CO_2

Type of reaction: **combustion**

3) **1** $Fe(OH)_2$ + **2** NaCl → **1** $FeCl_2$ + **2** NaOH

Type of reaction: **double displacement**

4) **1** Pb + **4** NO_3 → **1** $Pb(NO_2)_4$ + **2** O_2

Type of reaction: **single displacement**

5) **8** SO_3 → **1** S_8 + **12** O_2

Type of reaction: **decomposition**

6) **1** Ca + **2** H_2O → **1** $Ca(OH)_2$ + **1** H_2

Type of reaction: **single displacement**

7) **1** H_2O + **1** SO_3 → **1** H_2SO_4

Type of reaction: **synthesis**

8) **1** $MgSO_4$ → **1** MgO + **1** SO_3

Type of reaction: **decomposition**

For questions 9-15, predict the products of the reaction and identify the type of reaction taking place. (1 point for correctly predicting the products, 1 point for balancing the equation, 1 point for identifying the type of reaction)

9) **2** C_3H_6 + **9** O_2 → **6** CO_2 + **6** H_2O

Type of reaction: **combustion**

10) **1** Cu + **1** $Pb(NO_3)_2$ → **1** $Cu(NO_3)_2$ + **1** Pb

Type of reaction: **single displacement**

11) **1** H_2SO_4 + **2** KOH → **2** H_2O + **1** K_2SO_4

Type of reaction: **acid-base**

12) **1** $GaBr_3$ + **1** CoF_3 → **1** $CoBr_3$ + **1** GaF_3

Type of reaction: **double displacement**

13) **1** $Ti(OH)_3$+ **3** HNO_3 → **1** $Ti(NO_3)_3$ + **3** H_2O

Type of reaction: **acid-base**

14) **2** Li + **1** I_2 → **2** LiI

Type of reaction: **synthesis**

15) **2** $FeSO_3$ + **1** VS_2 → **2** FeS + **1** $V(SO_3)_2$

Type of reaction: **double displacement**

Suggested Grading Key

37 = A+
34 – 36 = A
32 – 33 = B+
30 – 31 = B
28 – 29 = C+
26 – 27 = C
25 = D+
23 – 24 = D
< 23 = F

Stoichiometry Quiz

Answer the following questions for the reaction:

$$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$$

1) How many grams of sodium sulfate can be made if I start with 50.0 grams of sodium hydroxide and an excess of sulfuric acid? (4 points)

2) If I actually made 20.0 grams of sodium sulfate, what would my percent yield be for this reaction? Is this a reasonable yield? (4 points)

3) How many grams of sulfuric acid would be required to make 2.5 moles of water? (4 points)

4) How many grams of sodium sulfate would also be formed in the reaction described in problem #3? Assume an excess of sodium hydroxide. (4 points)

For the problems on this page, use the following equation:

$$Fe_2(SO_4)_3 + 6\ LiNO_3 \rightarrow 3\ Li_2SO_4 + 2\ Fe(NO_3)_3$$

5) If I do the following reaction with 115 grams of iron (III) sulfate and 145 grams of lithium nitrate, how many grams of lithium sulfate will be formed? (6 points)

6) What is the limiting reagent in problem #5? (2 points)

7) How many grams of lithium sulfate would be formed if there were an excess of the limiting reagent? (4 points)

8) If 115 grams of lithium sulfate were formed in the reaction from problem #7, what is the percent yield of this reaction? Is this a reasonable yield? (4 points)

Stoichiometry Quiz - Solutions

Answer the following questions for the reaction:

$$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$$

1) How many grams of sodium sulfate can be made if I start with 50.0 grams of sodium hydroxide and an excess of sulfuric acid? (4 points)
88.8 grams

2) If I actually made 20.0 grams of sodium sulfate, what would my percent yield be for this reaction? Is this a reasonable yield? (4 points)
Since percent yield = (actual yield/theoretical yield) x 100, the percent yield for this reaction would be (20.0 grams / 88.8 grams) x 100 = 22.5%. This is a reasonable, though low, yield.

3) How many grams of sulfuric acid would be required to make 2.5 moles of water? (4 points)
120 grams (122.1 grams without significant figures)

4) How many grams of sodium sulfate would also be formed in the reaction described in problem #3? Assume an excess of sodium hydroxide. (4 points)
180 grams if you convert between moles of water and moles of sodium sulfate. (Without significant figures, 177.69 grams)

For the problems on this page, use the following equation:

$$Fe_2(SO_4)_3 + 6\ LiNO_3 \rightarrow 3\ Li_2SO_4 + 2\ Fe(NO_3)_3$$

5) If I do the following reaction with 115 grams of iron (III) sulfate and 145 grams of lithium nitrate, how many grams of lithium sulfate will be formed? (6 points)
94.8 grams

6) What is the limiting reagent in problem #5? (2 points)
iron (III) sulfate

7) How many grams of lithium sulfate would be formed if there were an excess of the limiting reagent? (4 points)
Adding an excess of the limiting reagent essentially makes the reagent that was not the limiting reagent in problem #5 into the limiting reagent. Since students should have computed the amount of lithium sulfate that would be formed in problem #5 – 116 grams.

8) If 115 grams of lithium sulfate were formed in the reaction from problem #7, what is the percent yield of this reaction? Is this a reasonable yield? (4 points)
115 / 116 x 100 = 99.1% yield. This is a reasonable and very high yield.

Suggested Grading Scale

32 = A+
29 – 31 = A
28 = B+
26 – 27 = B
24 – 25 = C+
23 = C
21 – 22 = D+
20 = D
< 20 = F

Gas Stoichiometry Quiz

1) Write a balanced equation for the combustion of methane. (2 points)

2) How many liters of methane gas are required to make 15 grams of water at standard temperature and pressure? (4 points)

3) How many liters of carbon dioxide can be formed from 12 liters of oxygen at STP? (4 points)

4) If 17.5 liters of methane react with 22.5 liters of oxygen, how many liters of carbon dioxide will be formed at STP? (6 points)

Gas Stoichiometry Quiz – Solutions

1) Write a balanced equation for the combustion of methane. (2 points)

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

2) How many liters of methane gas are required to make 15 grams of water at standard temperature and pressure? (4 points)
11 liters

3) How many liters of carbon dioxide can be formed from 12 liters of oxygen at STP? (4 points)
6 liters (atmospheric temperature and pressure are not important in solving this problem)

4) If 17.5 liters of methane react with 22.5 liters of oxygen, how many liters of carbon dioxide will be formed at STP? (6 points)
11.3 liters (Again, atmospheric temperature and pressure are not important to this problem, as both the products and reagents are under the same reaction conditions.)

Suggested Grading Scale

16 = A+
15 = A
14 = B+
13 = B
12 = C+
11 = D+
10 = D
< 10 = F

Phase Changes and Calorimetry Quiz

1) What happens to make substances undergo phase changes? As your example, use the solid-liquid transition between ice and liquid water. (6 points)

2) How much energy does it take to heat 45 grams of water from -25^0 C to 25^0 C? $C_p\ [H_2O_{(s)}] = 2.03$ J / g $\cdot\ ^0$C, $C_p\ [H_2O_{(l)}] = 4.18$ J / g $\cdot\ ^0$C, $\Delta H_{fusion}(H_2O) = 6.00$ kJ / mole (8 points)

3) How much energy does it take to heat 125 grams of water ice at a temperature of 0^0 C to a temperature of 175^0 C? $\Delta H_{vap}(H_2O) = 40.6$ kJ / mol, $C_p\ [H_2O_{(g)}] = 4.22$ J / g $\cdot\ ^0$C (10 points)

4) Explain how calorimetry works. (6 points)

5) When 5.00 grams of naphthalene ($C_{10}H_8$) are burned in a bomb calorimeter, the temperature of the water bath rises from 10.0^0 C to 58.2^0 C. If the volume of the water bath is 1.000 L and the heat capacity of liquid water is 4.18 J / g $\cdot$ ^{0}C, what is the heat of combustion of naphthalene? (12 points)

6) If you built a calorimeter in which the bomb was not properly thermally isolated, what would be the effect on the accuracy of your measurements? Be specific! (6 points)

Phase Changes and Calorimetry Quiz - Solutions

1) What happens to make substances undergo phase changes? As your example, use the solid-liquid transition between ice and liquid water. (6 points)

The main intermolecular force in water is hydrogen bonding. This strong intermolecular force serves to hold the water molecules in ice crystals in place with a lot of force. As the temperature of the ice increases, the thermal motion of the water molecules becomes greater until the water molecules suddenly begin moving around with relation to one another. This sudden movement from a lattice-like structure to a more disordered structure is the melting transition between solid and liquid. Generally, melting, vaporization, and sublimation are all processes in which the thermal energy of the particles becomes stronger than the intermolecular forces holding them together.

2) How much energy does it take to heat 45 grams of water from -25^0 C to 25^0 C? $C_p\ [H_2O_{(s)}] = 2.03$ J / g $\cdot\ ^0$C, $C_p\ [H_2O_{(l)}] = 4.18$ J / g $\cdot\ ^0$C, $\Delta H_{fusion}(H_2O) = 6.00$ kJ / mole (8 points)

<u>Step 1:</u> Heat the ice from -25^0 C to 0^0 C (2 points): 2300 J (2283.8 J without significant figures)
<u>Step 2:</u> Melt the ice (2 points): 15,000 J (15 kJ)
<u>Step 3:</u> Heat the water (2 points): 4700 J (4702.5 J without significant figures).
<u>Grand total</u> (2 points): Add them all together to get 22,000 J or 22 kJ.

3) How much energy does it take to heat 125 grams of water ice at a temperature of 0^0 C to a temperature of 175^0 C? $\Delta H_{vap}(H_2O) = 40.6$ kJ / mol, $C_p\ [H_2O_{(g)}] = 4.22$ J / g $\cdot\ ^0$C (10 points)

<u>Step 1:</u> Melt the ice (2 points): 41,600 J
<u>Step 2:</u> Heat the water (2 points): 52,300 J
<u>Step 3:</u> Boil the water (2 points): 282,000 J
<u>Step 4:</u> Heat the steam (2 points): 39,600 J
<u>Grand total</u> (2 points): Add them all together to get 415,500 J, or 415.5 kJ

4) Explain how calorimetry works. (6 points)

2 points each:

- **In calorimetry, a chemical reaction takes place in a container in which all of the heat produced or absorbed can be collected.**
- **In bomb calorimetry, the chemical reaction takes place in a container called the "bomb" which is in thermal equilibrium with a water bath.**
- **Because the heat capacity of water is well known and easily measurable, the equation $\Delta H = mC_p\Delta T$ can be used to determine the amount of heat given off.**

5) When 5.00 grams of naphthalene ($C_{10}H_8$) are burned in a bomb calorimeter, the temperature of the water bath rises from 10.0^0 C to 58.2^0 C. If the volume of the water bath is 1.000 L and the heat capacity of liquid water is 4.18 J / g $\cdot$ ^{0}C, what is the heat of combustion of naphthalene? (12 points)

3 points each:

- **There are 0.0391 moles of naphthalene in the bomb**
- **$\Delta H = mC_p\Delta T$**
- **The amount of heat absorbed by the water is equal to (1000.0 g x 4.18 J / g $\cdot$ ^{0}C x 48.2^0 C) = 201 kJ.**
- **Because 201 kJ is the amount of energy given off by 0.0391 moles of naphthalene, we can scale this up to determine that 5140 kJ are given off by one mole of naphthalene. This is the heat of combustion of naphthalene.**

(Note: This is very close to the actual heat of combustion of naphthalene, which is 5154.2 kJ/mol)

6) If you built a calorimeter in which the bomb was not properly thermally isolated, what would be the effect on the accuracy of your measurements? Be specific! (6 points)

Because heat is generated in bomb calorimeters, the result would be that some of the heat would be released into the environment, giving an artificially low reading for the heat of combustion of whatever substance was being tested.

<u>Suggested Grading Scale</u>

48 = A+
43 – 47 = A
41 – 42 = B+
38 – 40 = B
36 – 37 = C+
34 – 35 = C
31 – 33 = D+
29 – 30 = D
< 29 = F

Heat of Reaction Quiz

1) In the space below, write the energy diagram for a reaction in which compounds A and B combine to form compound C. This reaction is exothermic and gives off 100 kJ of energy per mole. In this diagram, show the following: reagents, products, heat of reaction, activation energy, and transition state. Additionally, the x and y-axes of the diagram need to be labeled properly. (10 points)

2) Define the following terms: (2 points each)

- endothermic:
- activation energy:
- spontaneous:
- reversible:
- heat capacity:

3) Calculate the heat of reaction for the following reaction: (8 points)

$$\mathbf{Fe + 2\ AgCl \rightarrow 2\ Ag + FeCl_2 \qquad \Delta H = ?}$$

Given the following information:

$Ag + ½\ Cl_2 \rightarrow AgCl \qquad \Delta H = -63.5$ kJ/mole

$Fe + Cl_2 \rightarrow FeCl_2 \qquad \Delta H = -344.4$ kJ/mole

4) Calculate the heat of reaction for the following reaction: (8 points)

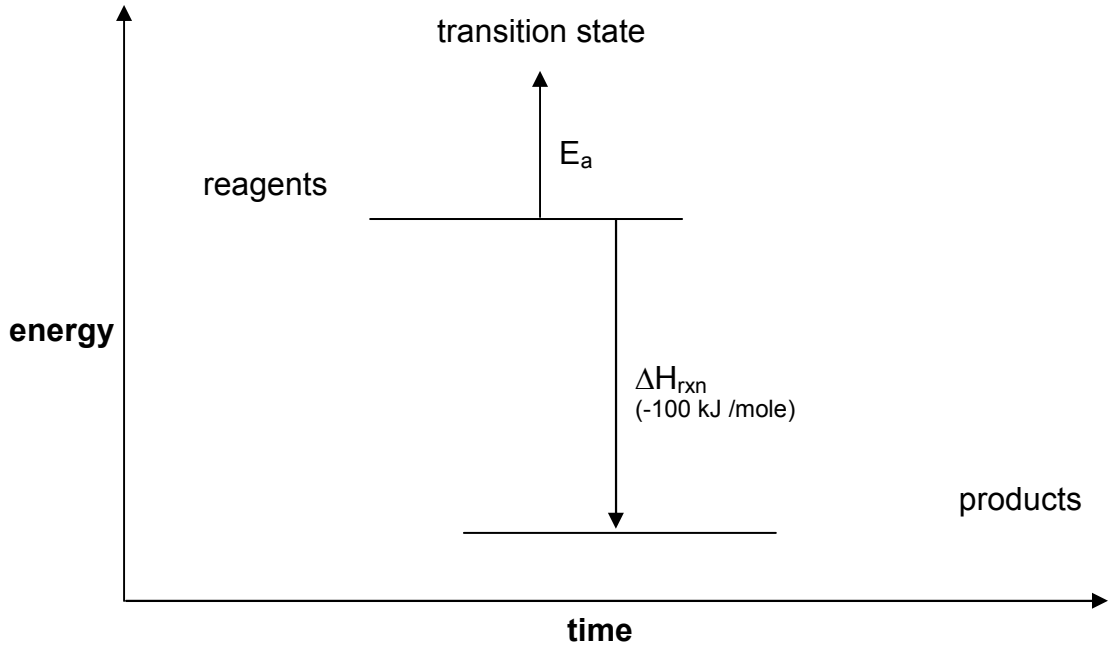
$$\mathbf{2\ MgO + PbCl_4 \rightarrow 2\ MgCl_2 + PbO_2}$$

Given the following information:

Compound	ΔH_f^0 (kJ/mol)
$MgCl_2$	- 641.3
MgO	- 598.0
$PbCl_4$	- 329.3
PbO_2	- 277.4

Heat of Reaction Quiz – Solutions

1) In the space below, write the energy diagram for a reaction in which compounds A and B combine to form compound C. This reaction is exothermic and gives off 100 kJ of energy per mole. In this diagram, show the following: Reagents, products, heat of reaction, activation energy, and transition state. Additionally, the x and y-axes of the diagram need to be labeled properly. (10 points)



Grading scale for problem 1:

Give 1 point for labeling each of the following:

- **products**
- **reagents**
- **activation energy**
- **"ΔH_{rxn}"**
- **"- 100 kJ/mol" (sign must be correct)**
- **transition state**
- **x – axis labeled "time"**
- **y – axis labeled "energy"**

Give two points for correctly showing the products lower on the energy coordinate than the reagents

2) Define the following terms: (2 points each)

- endothermic: **Anything that absorbs energy.**
- activation energy: **The amount of energy required for a reaction to proceed to completion.**
- spontaneous: **Any process which occurs on its own. Frequently used to describe any reaction with a negative free energy.**
- reversible: **A process in which the products can be used to reproduce the same reagents that you started with in the first place by going backwards on the identical reaction pathway. From a theoretical standpoint, all processes are reversible (via the principle of microscopic reversibility). From a practical standpoint, very few (if any) chemical processes are reversible.**
- heat capacity: **The amount of energy required to raise the temperature of one gram of a substance by one degree Celsius.**

3) Calculate the heat of reaction for the following reaction: (8 points)

$Fe + 2\ AgCl \rightarrow 2\ Ag + FeCl_2$ $\Delta H = ?$

Given the following information:

$Ag + \frac{1}{2}\ Cl_2 \rightarrow AgCl$ $\Delta H = 63.5$ kJ/mole

$Fe + Cl_2 \rightarrow FeCl_2$ $\Delta H = -344.4$ kJ/mole

By manipulating the given equations, you can find that:

$2\ AgCl \rightarrow 2\ Ag + Cl_2$ $\Delta H = 127.0$ kJ/mole

$Fe + Cl_2 \rightarrow FeCl_2$ $\Delta H = -344.4$ kJ/mole

$Fe + 2\ AgCl \rightarrow 2\ Ag + FeCl_2$ $\Delta H = -217.4$ kJ/mole

4) Calculate the heat of reaction for the following reaction: (8 points)

$$\mathbf{2\ MgO + PbCl_4 \rightarrow 2\ MgCl_2 + PbO_2}$$

Given the following information:

Compound	ΔH_f^0 (kJ/mol)
$MgCl_2$	- 641.3
MgO	- 598.0
$PbCl_4$	- 329.3
PbO_2	- 277.4

$\Delta H_{rxn} = \Sigma\Delta H_{products} - \Sigma\Delta H_{reagents}$

In this case, this is equal to:

ΔH_{rxn} **= [(2 x –641.3) + (–277.4)] – [(2 x –598.0) + (–329.3)] kJ/mol**
= [–1283 –277.4] – [–1196 – 329.3] kJ/mol
= [–1560 + 1525] kJ/mol
= – 35 kJ/mol

Suggested Grading Scale

36 = A+
32 – 35 = A
31 = B+
29 – 30 = B
27 – 28 = C+
25 – 26 = C
23 – 24 = D+
22 = D
< 22 = F

Entropy and Free Energy Quiz

1) Explain the difference between “enthalpy” and “entropy”. (3 points)

2) Name one process during which the entropy of the system increases. (3 points)

3) Determine the entropy change for the following reaction:

$$\mathbf{1\ C_2H_6O_{(l)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(g)}}$$

Given the following information: (6 points)

Compound	S (J / K · mol)
$C_2H_6O_{(l)}$	161
$CO_{2(g)}$	214
$H_2O_{(g)}$	189
$O_{2(g)}$	205

4) Explain why the entropy of a system increases as the temperature increases. (4 points)

5) Define “free energy”. (3 points)

6) Determine the conditions under which the following changes will take place spontaneously or nonspontaneously: (1 point each)

ΔS	ΔH	Spontaneous or nonspontaneous? (write one)
+	+	
+	-	
-	+	
-	-	

7) Ethylene gas burns in oxygen to form carbon dioxide and water by the following equation:

$$1\ C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$$

If ΔH for this reaction is –1410.1 kJ/mol and ΔS for this reaction is – 28.0 J / K · mol, will this reaction be spontaneous at a temperature of 265^0 C? (8 points)

Entropy and Free Energy Quiz – Solutions

1) Explain the difference between "enthalpy" and "entropy". (3 points)
Enthalpy refers to the total energy content of a system as defined by the amount of energy devoted to bonding. Entropy refers to the total randomness of a system, determined by temperature and the number of particles in the system.

2) Name one process during which the entropy of the system increases. (3 points)
Any process in which the final product is more disordered should receive three points. This can include chemical processes where the number of product molecules is greater than the number of reagent molecules or "real world" processes where something gets messier than it started.

3) Determine the entropy change for the following reaction:

$$\mathbf{1\ C_2H_6O_{(l)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(g)}}$$

Given the following information: (6 points)

Compound	S (J / K · mol)
$C_2H_6O_{(l)}$	161
$CO_{2(g)}$	214
$H_2O_{(g)}$	189
$O_{2(g)}$	205

ΔS = [entropy of products] – [entropy of reagents]
= [2(214) + 3(189)] – [1(161) + 3(205)] J / K · mol
= [995 – 776] J / K · mol
= 219 J / K · mol

4) Explain why the entropy of a system increases as the temperature increases. (4 points)
This can be thought of in one of two ways:
- **The units of entropy are J / K · mol, meaning that the amount of entropy is measured per number of degrees of temperature (in Kelvins). According to this, the higher the temperature, the higher the entropy.**
- **From a qualitative standpoint, molecules move around faster and get more disordered as the temperature increases. This is why entropy goes up as temperature goes up.**

5) Define "free energy". (3 points)
Free energy can be defined as the amount of energy a system has available to do work. This explains why a negative value of ΔG means that a reaction is "spontaneous" – after all, if a process will result in lower energy it must take place.

6) Determine the conditions under which the following changes will take place spontaneously or nonspontaneously: (1 point each)

ΔS	ΔH	Spontaneous or nonspontaneous? (write one)
+	+	spontaneous at high temperatures.
+	-	reaction is always spontaneous
-	+	reaction is never spontaneous
-	-	spontaneous at low temperatures

7) Ethylene gas burns in oxygen to form carbon dioxide and water by the following equation:

$$1\ C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$$

If ΔH for this reaction is –1410.1 kJ/mol and ΔS for this reaction is – 28.0 J / K · mol, will this reaction be spontaneous at a temperature of 265^0 C? (8 points)

$\Delta G = \Delta H - T\Delta S$
$= -1{,}410.1$ kJ / mol – 538(28.0) J
$= -1{,}430$ kJ / mol (-1,425,164 J /mol without rounding)

(Note: Common mistakes in this problem include failure to convert degrees Celsius to Kelvins and failure to recognize the difference between <u>kilo</u>joules and joules as the units for enthalpy and entropy.

<u>Suggested Grading Scale</u>
31 = A+
28 – 30 = A
27 = B+
25 – 26 = B
24 = C+
22 – 23 = C
21 = D+
19 – 20 = D
< 19 = F

Kinetic Molecular Theory Quiz

1) What are the four properties of an "ideal gas", according to the kinetic molecular theory? (2 points each)

-
-
-
-

2) Convert 340^0 C to Kelvins. (2 points)

3) Convert 340 mm Hg to atmospheres. (3 points)

4) List a unit of pressure other than mm Hg or atmospheres and give the conversion factor of that unit to atmospheres. (2 points)

5) What conditions are meant when we refer to “STP”? (2 points)

6) In your own words, explain Avogadro’s Law. (4 points)

7) When a toy balloon is filled with helium, it “floats”. However, if you fill the same balloon with an equivalent volume of carbon dioxide, it sinks. Explain this phenomenon, using what you’ve learned about gases. (4 points)

Kinetic Molecular Theory Quiz - Solutions

1) What are the four properties of an "ideal gas", according to the kinetic molecular theory? (2 points each)

- **The particles in an ideal gas are infinitely small.**
- **The particles in an ideal gas move in random straight lines until they collide with the walls of the container or with other ideal gas particles.**
- **The particles in an ideal gas don't interact with one another.**
- **The kinetic energy of the particles in an ideal gas is directly proportional to the temperature of the gas in Kelvins.**

2) Convert 340^0 C to Kelvins. (2 points)
Because K = ^{0}C + 273, 340^0 C is equal to (340 + 273) or 613 K

3) Convert 340 mm Hg to atmospheres. (3 points)
Because there are 760 mm Hg in one atmosphere, the conversion which should be made is (340 / 760) atm, or 0.45 atm.

4) List a unit of pressure other than mm Hg or atmospheres and give the conversion factor of that unit to atmospheres. (2 points)

Any of the following is worth 2 points:

Unit	Conversion factor
torr	760 torr = 1 atm
bar	1.01 bar = 1 atm
Pascal (Pa)	101 kPa = 1 atm
pounds / inch^2 (PSI)	14.7 psi = 1 atm
kg / centimeter^2	1.03 kg / cm^2 = 1 atm

5) What conditions are meant when we refer to "STP"? (2 points)
One point for mentioning that standard temperature is 273 K or 0^0 C and one point for mentioning that standard pressure is one atmosphere.

6) In your own words, explain Avogadro's Law. (4 points)
The volume of an ideal gas is directly proportional to the number of moles of gas present. Stated mathematically, V = an

7) When a toy balloon is filled with helium, it "floats". However, if you fill the same balloon with an equivalent volume of carbon dioxide, it sinks. Explain this phenomenon, using what you've learned about gases. (4 points)
According to Avogadro's Law, the volume of a gas is proportional only to the number of moles of gas present, not to the mass of gas present. Although both balloons have the same volume, the one containing carbon dioxide weighs more than the one filled with helium because carbon dioxide has a molar mass of 44 grams/mole while helium has a molar mass of only 4 grams/mole. Since density = mass / volume and the volumes are the same, the density of the carbon dioxide balloon has a much higher density than the one containing helium.

Suggested Grading Scale

25 = A+
23 – 24 = A
22 = B+
20 – 21 = B
19 = C+
18 = C
17 = D+
15 – 16 = D
< 15 = F

Gas Laws Quiz

1) If a toy balloon initially has a volume of 1.50 liters at a temperature of 25^0 C, what will the volume be if the temperature rises to 45^0 C? Assume constant pressure. (4 points)

2) A bag of chips has a volume of 755 mL at a pressure of 1.00 atmospheres. If I ship the bag of chips from New York to Denver (where the atmospheric pressure is 0.800 atmospheres), what will the new volume of the bag be? Assume constant temperature. (4 points)

3) If the bag of chips from problem #2 was at an initial temperature of 25^0 C in New York and the temperature in Denver was 5^0 C, what would the final volume of the bag be? (4 points)

4) You are an investigator for the humane society that's investigating animal cruelty at pet stores. A set of hamster tunnels at the pet store has a volume of 500.0 L, a pressure of 0.95 atm, and can hold 30.0 moles of air.

   a) What is the temperature inside the hamster tunnels? (4 points)

   b) Explain whether or not the hamsters are being mistreated. (2 points)

5) State Dalton's law of partial pressures. (2 points)

6) A stopcock separates two bottles from one another. The first bottle contains argon and has a volume of 2.0 liters and a pressure of 1.5 atmospheres. The second bottle contains nitrogen and has a volume of 3.5 liters and a pressure of 1.8 atmospheres. The temperature is 25^0 C.

a) How many moles of gas are in the first bottle? (4 points)

b) How many moles of gas are in the second bottle? (4 points)

c) If the stopcock is opened, what will be the total pressure of the two bottles? (4 points)

d) What will the mole fraction of nitrogen be in the bottles? (4 points)

e) What will the partial pressure of nitrogen be in the bottles? (4 points)

Gas Laws Quiz – Solutions

1) If a toy balloon initially has a volume of 1.50 liters at a temperature of 25^0 C, what will the volume be if the temperature rises to 45^0 C? Assume constant pressure. (4 points)
Using Charles's law, 1.60 liters. (A common wrong answer will be 2.7 liters – this is the answer found if students forget to convert between degrees Celsius and Kelvins)

2) A bag of chips has a volume of 755 mL at a pressure of 1.00 atmospheres. If I ship the bag of chips from New York to Denver (where the atmospheric pressure is 0.800 atmospheres), what will the new volume of the bag be? Assume constant temperature. (4 points)
Using Boyle's law, 944 mL.

3) If the bag of chips from problem #2 was at an initial temperature of 25^0 C in New York and the temperature in Denver was 5^0 C, what would the final volume of the bag be? (4 points)
Using the combined gas law, 880 mL. (If students forget to convert from degrees Celsius to Kelvins, their answer will be 189 mL)

4) You are an investigator for the humane society that's investigating animal cruelty at pet stores. A set of hamster tunnels at the pet store has a volume of 500.0 L, a pressure of 0.95 atm, and can hold 30.0 moles of air.

   a) What is the temperature inside the hamster tunnels? (4 points)
   Using the ideal gas law, 193 K.

   b) Explain whether or not the hamsters are being mistreated. (2 points)
   Yes, because 193 K corresponds to a temperature of -80^0 C.

5) State Dalton's law of partial pressures. (2 points)
$P_{tot} = P_a + P_b + \ldots$

6) A stopcock separates two bottles from one another. The first bottle contains argon and has a volume of 2.0 liters and a pressure of 1.5 atmospheres. The second bottle contains nitrogen and has a volume of 3.5 liters and a pressure of 1.8 atmospheres. The temperature is 25^0 C.

a) How many moles of gas are in the first bottle? (4 points)
0.12 moles

b) How many moles of gas are in the second bottle? (4 points)
0.26 moles

c) If the stopcock is opened, what will be the total pressure of the two bottles? (4 points)
1.68 atm

d) What will the mole fraction of nitrogen be in the bottles? (4 points)
(0.26 / 0.38) = 0.68

e) What will the partial pressure of nitrogen be in the bottles? (4 points)
0.68 x 1.68 atm = 1.1 atm

Suggested Grading Scale

40 = A+
36 – 39 = A
34 – 35 = B+
32 – 33 = B
30 – 31 = C+
28 – 29 = C
26 – 27 = D+
25 – 26 = D
< 25 = F

Molecular Motion Quiz

1) What is the root mean square velocity of sulfur dioxide molecules at a temperature of 25^0 C? R = 8.314 J / K · mol. (4 points)

2) Define “mean free path”. (2 points)

3) What is the difference between effusion and diffusion? (4 points)

4) Calculate the ratio of the effusion rates of water vapor and oxygen gas. (4 points)

5) On the back of this sheet, sketch a plot showing particle velocity vs. temperature for an ideal gas. (6 points)

Molecular Motion Quiz – Solutions

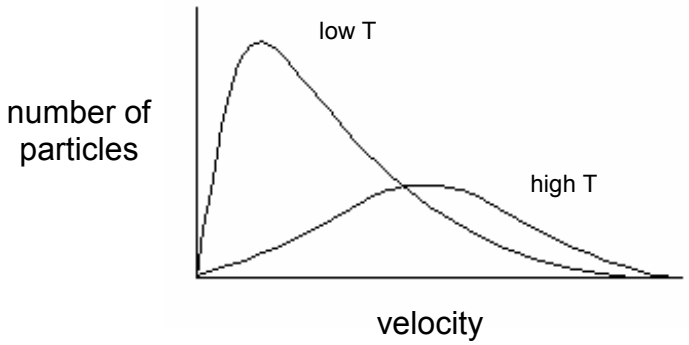
1) What is the root mean square velocity of sulfur dioxide molecules at a temperature of 25^0 C? R = 8.314 J / K · mol. (4 points)
$u_{rms} = (3RT/M)^{1/2} = [(3 \times 8.314 \times 298) / 0.0641]^{1/2} = 341$ m / sec

2) Define "mean free path". (2 points)
The mean free path of a substance is the average distance a particle can move before hitting another particle. Typically, the mean free path of real gases is measured in tenths of microns.

3) What is the difference between effusion and diffusion? (4 points)
Effusion is the rate at which a gas flows through a small opening into an evacuated chamber. Diffusion is the rate at which a gas mixes with another gas.

4) Calculate the ratio of the effusion rates of water vapor and oxygen gas. (4 points)
Using Graham's law of effusion, 1.33.

5) On the back of this sheet, sketch a plot showing particle velocity vs. temperature for an ideal gas. (6 points)



1 point each for labeling each axis correctly, each curve, and correctly labeling the curves with either "low T" or "high T".

Suggested Grading Scale

20 = A+
18 – 19 = A
17 = B+
16 = B
15 = C+
14 = C
13 = D+
12 = D
< 12 = F

Phase Diagrams Quiz

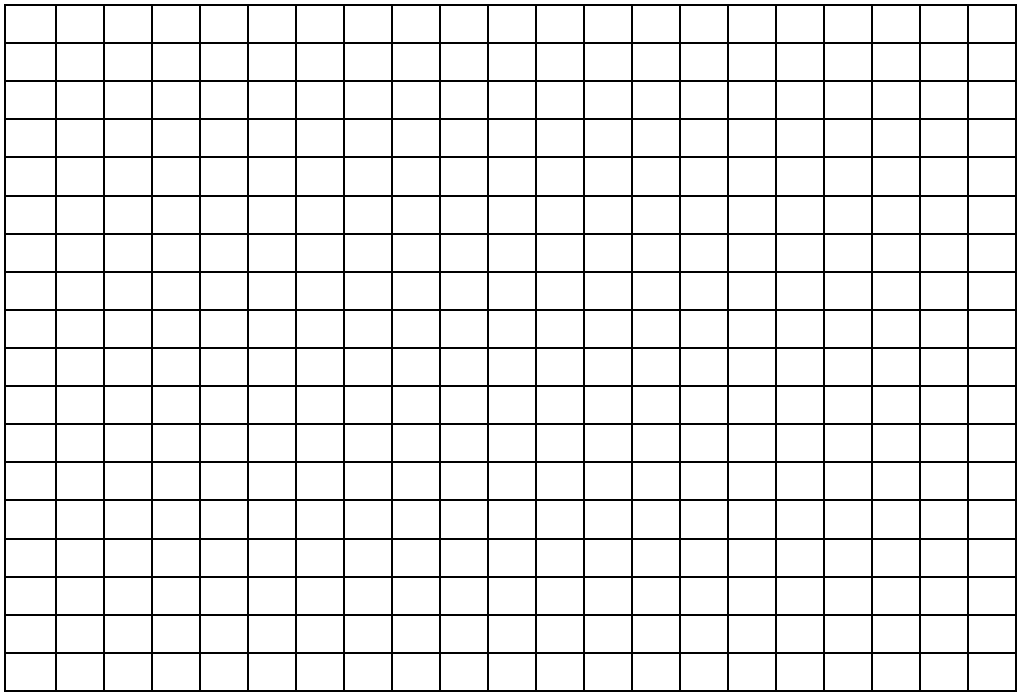
1) Define the following terms. (2 points each)

- triple point:

- critical point:

- sublimation:

2) On the graph below, draw the phase diagram for the substance X, which has the data described below. Make sure you label the sublimation boundary, the vaporization boundary, the fusion boundary, the triple point, the critical point, the x- and y-axis (with units), and each of the three phases. (12 points)
   - It sublimes at a temperature of 50 K and a pressure of 1.0 atm.
   - It melts at a temperature of 150 K and a pressure of 6.0 atm.
   - It boils at a temperature of 200 K and a pressure of 2.5 atm.
   - The triple point is at a temperature of 100 K and a pressure of 2.0 atm.
   - The critical point is at a temperature of 300 K and a pressure of 3.0 atm.



3) The triple point of water exists at a temperature of 0.0098 K and a pressure of 0.0060 atm. However, if you place an ice cube into a pot of boiling water you can get the gas, liquid, and solid phases to come into direct contact with one another at a temperature of 273 K and a pressure of 1.00 atm. By doing this experiment, have you actually changed the triple point of water, or has something else happened? Explain. (5 points)

4) Explain what it means if we say that a substance has been "supercooled". (4 points)

5) What is a "supercritical liquid"? (4 points)

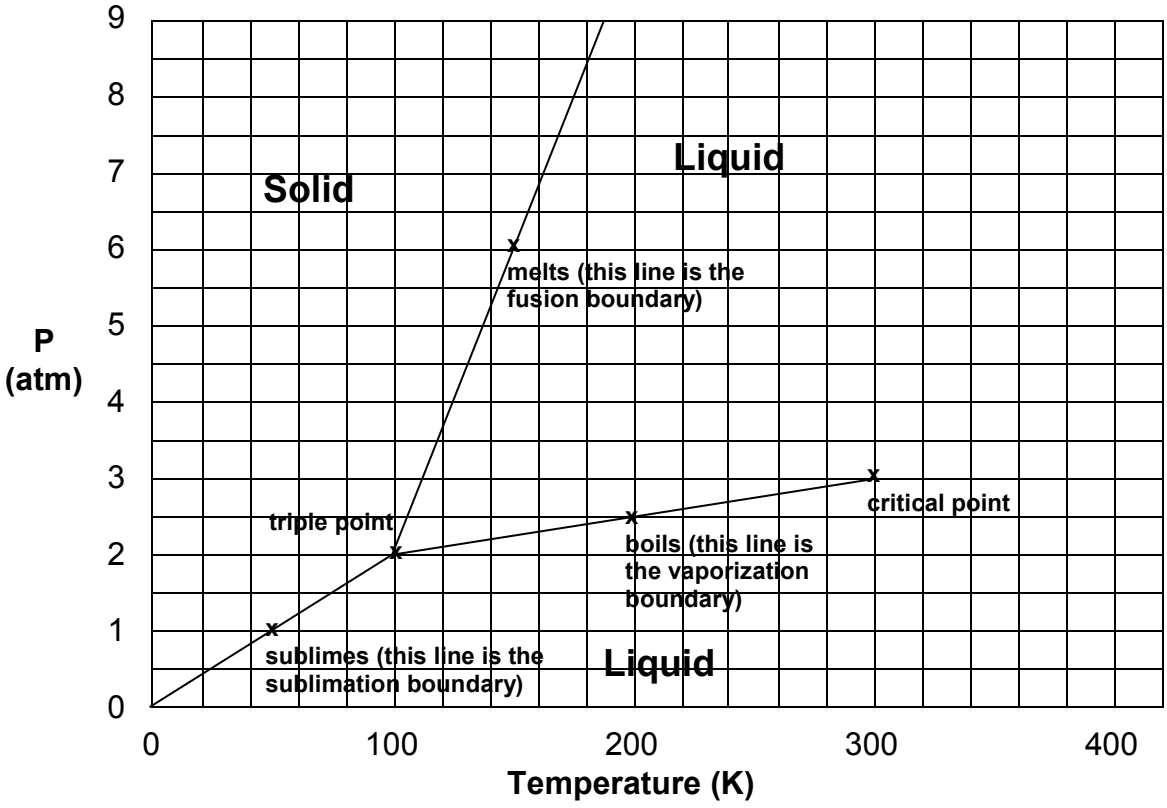
Phase Diagrams Quiz – Solutions

1) Define the following terms. (2 points each)

- triple point: **The point at which the solid, liquid, and gas phases of a substance are in equilibrium with one another.**
- critical point: **The highest condition of temperature and pressure at which it is possible to make the liquid – vapor transition.**
- sublimation: **When a solid is converted to a gas.**

2) On the graph below, draw the phase diagram for the substance X, which has the data described below. Make sure you label the sublimation boundary, the vaporization boundary, the fusion boundary, the triple point, the critical point, the x- and y-axis (with units), and each of the three phases. (12 points, **assign one point for each**)

- It sublimes at a temperature of 50 K and a pressure of 1.0 atm.
- It melts at a temperature of 150 K and a pressure of 6.0 atm.
- It boils at a temperature of 200 K and a pressure of 2.5 atm.
- The triple point is at a temperature of 100 K and a pressure of 2.0 atm.
- The critical point is at a temperature of 300 K and a pressure of 3.0 atm.



3) The triple point of water exists at a temperature of 0.0098 K and a pressure of 0.0060 atm. However, if you place an ice cube into a pot of boiling water you can get the gas, liquid, and solid phases to come into direct contact with one another at a temperature of 273 K and a pressure of 1.00 atm. By doing this experiment, have you actually changed the triple point of water, or has something else happened? Explain. (5 points)
Although all three phases of water exist at this temperature in pressure, the triple point is defined as being the conditions of temperature and pressure at which all three phases exist in equilibrium. It should be instantly clear that although the liquid and gas phases may be in equilibrium under the conditions stated, the solid phase will quickly melt.

4) Explain what it means if we say that a substance has been "supercooled". (4 points)
If a substance has been supercooled, it exists as a liquid below the normal melting point. This generally happens when there is a lack of nucleation centers to cause crystallization of the liquid.

5) What is a "supercritical liquid"? (4 points)
A supercritical liquid is the state of matter that exists past the critical point of a substance. Not quite liquid and not quite gas, the supercritical "phase" often displays unusual properties.

<u>Suggested Grading Scale</u>

31 = A+
28 – 30 = A
27 = B+
25 – 26 = B
24 = C+
22 – 23 = C
21 = D+
19 – 20 = D
< 19 = F

Solutions and Molarity Quiz

1) If you were given a solution, how could you determine if it were saturated? Your answer should describe some test you would perform. (4 points)

2) Explain the difference between a solution and a suspension. (4 points)

3) List two examples of suspensions and two examples of solutions that you might run into in your everyday life. (1 point each)

Suspension 1: _____

Suspension 2: _____

Solution 1: _____

Solution 2: _____

4) Describe how you would make 750 mL of a 0.500 M NaOH solution if you were given only a 1000 mL graduated cylinder, an unlimited amount of NaOH and distilled water, and a 1000 mL beaker. (8 points)

5) What is the molarity of a solution that contains 4.50 moles of lithium chloride in 10.5 L of solution? (3 points)

6) What is the molarity of a solution that contains 4.50 grams of lithium chloride in 10.5 L of solution? (5 points)

7) What is the molarity of a solution that contains 45.0 grams of lithium chloride in 1050 mL of solution? (6 points)

8) If I added 125 mL of water to 475 mL of a 0.25 M Na_2CO_3 solution, what would the molarity of the resulting solution be? (4 points)

Solutions and Molarity Quiz – Solutions

1) If you were given a solution, how could you determine if it were saturated? Your answer should describe some test you would perform. (4 points)
Add some more solute to the solution. If it dissolves, then the solution was not saturated to start with.

2) Explain the difference between a solution and a suspension. (4 points)
A solution is formed when a compound actually dissociates and the water molecules attach themselves to the separated components of the substance being dissolved. A suspension is when a solid consisting of many small particles is floating loose in a liquid. When a solution is left alone for a long period of time, it appears unchanged. However, when a suspension is left alone, the particles sink to the bottom.

3) List two examples of suspensions and two examples of solutions that you might run into in your everyday life. (1 point each)
Examples of suspensions include anything where there are small particles in a seemingly homogeneous mixture that eventually settle to the bottom. Common examples are milk, mustard, ketchup, peanut butter, or mud. Examples of solutions include anything where something has dissolved in a solvent. Common examples are soda, Kool Aid, juice (without pulp), or seawater.

4) Describe how you would make 750 mL of a 0.500 M NaOH solution if you were given only a 1000 mL graduated cylinder, an unlimited amount of NaOH and distilled water, and a 1000 mL beaker. (8 points)
Give two points for each of the following:

- **M = moles / liters**
- **0.375 moles of NaOH will be required to make the solution.**
- **15 grams of NaOH will be required to make the solution.**
- **The solution may be made by placing the sodium hydroxide into the graduated cylinder and adding water until the total volume of the solution is equal to 750 mL.**

5) What is the molarity of a solution that contains 4.50 moles of lithium chloride in 10.5 L of solution? (3 points)
M = moles / liters = (4.50 / 10.5) M = 0.429 M

6) What is the molarity of a solution that contains 4.50 grams of lithium chloride in 10.5 L of solution? (5 points)
- **Give two points for determining that 4.50 grams of LiCl is equivalent to 0.106 moles.**
- **Give three points for determining that the molarity is equal to (0.106 / 10.5) M = 0.0101 M**

7) What is the molarity of a solution that contains 45.0 grams of lithium chloride in 1050 mL of solution? (6 points)
- **Give two points for determining that 45.0 grams of LiCl is equivalent to 1.06 moles.**
- **Give one point for determining that 1050 mL of solution is equivalent to 1.05 L.**
- **Give three points for determining that the molarity is equal to (1.06 / 1.05) M = 1.01 M**

8) If I added 125 mL of water to 475 mL of a 0.25 M Na_2CO_3 solution, what would the molarity of the resulting solution be? (4 points)
- **Give two points for showing that $M_1V_1 = M_2V_2$**
- **Give two points for showing that in this case:**

(0.25 M)(475 mL) = (x)(600. mL)

x = 0.20 M

(Note: A common mistake is for students to mistakenly guess that V_2 is equivalent to 125 mL rather than 600. mL.)

<u>Suggested Grading Scale</u>

38 = A+
34 – 37 = A
33 = B+
30 – 32 = B
29 = C+
27 – 28 = C
25 – 26 = D+
23 – 24 = D
< 23 = F

Solubility Quiz

1) Explain the statement “like dissolves like”. (4 points)

2) Explain why sodium chloride is soluble in water but not in isopropanol. (4 points)

3) Explain what happens on a molecular level when a crystal of lithium chloride dissolves in water. (6 points)

4) Indicate which of the following molecules are polar by writing “polar” or “nonpolar” in the blank next to them. (1 point each)

   a) carbon dioxide _____

   b) carbon tetrachloride _____

   c) nitrogen tribromide _____

   d) sodium acetate _____

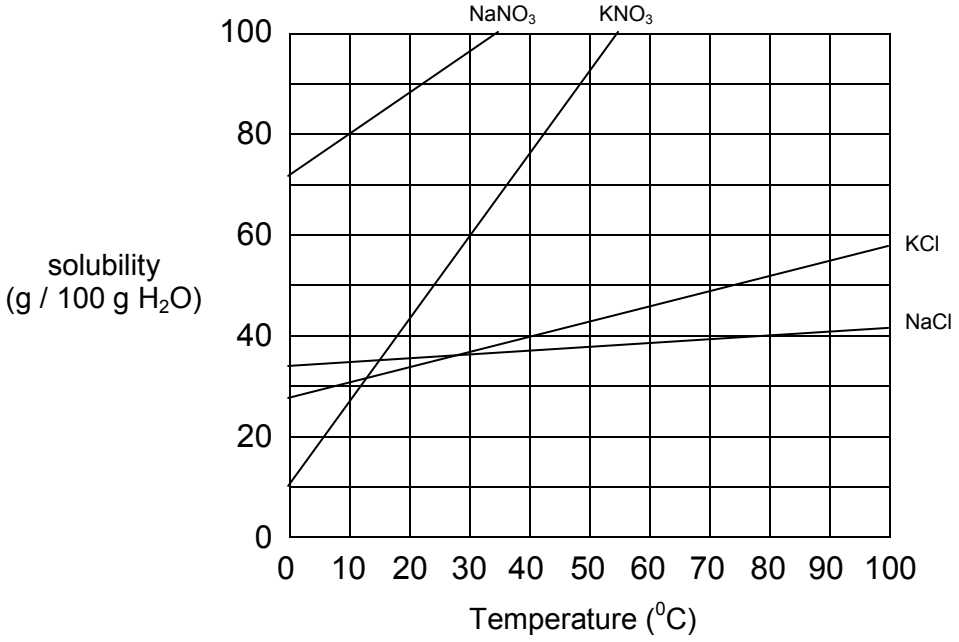
   e) CH_2Cl_2 _____

   f) nitrogen _____

5) Explain the differences between covalent, polar covalent, and ionic compounds. (6 points)

6) Soda is observed to go flat more quickly when warm than when cold. Explain this phenomenon. (4 points)

7) Using the graph below, answer the following questions about the solubility of ionic compounds in water. (1 point each)



a) Which compound is most soluble at 45^0 C? _____

b) Which compound is least soluble at 35^0 C? _____

c) Which compound has the greatest range of solubilities over the temperature range shown?

_____

Solubility Quiz - Solutions

1) Explain the statement “like dissolves like”. (4 points)
Polar solvents tend to dissolve polar solutes and nonpolar solvents tend to dissolve nonpolar solutes.

2) Explain why sodium chloride is soluble in water but not in isopropanol. (4 points)
Sodium chloride is a polar solute. Water is a polar solvent, and isopropanol is relatively nonpolar. Because the polarity of water is most close to the polarity of sodium chloride, sodium chloride is far more soluble in water than isopropanol.

3) Explain what happens on a molecular level when a crystal of lithium chloride dissolves in water. (6 points)
- **The water molecules attach themselves to the lithium and chloride ions. (1 point)**
- **Because the energy of the interaction between the water molecules and the ions is lower than the energy of the interaction between the ions alone, lithium chloride dissolves in water. (5 points)**

4) Indicate which of the following molecules are polar by writing “polar” or “nonpolar” in the blank next to them. (1 point each)

a) carbon dioxide **nonpolar**

b) carbon tetrachloride **nonpolar**

c) nitrogen tribromide **polar**

d) sodium acetate **polar**

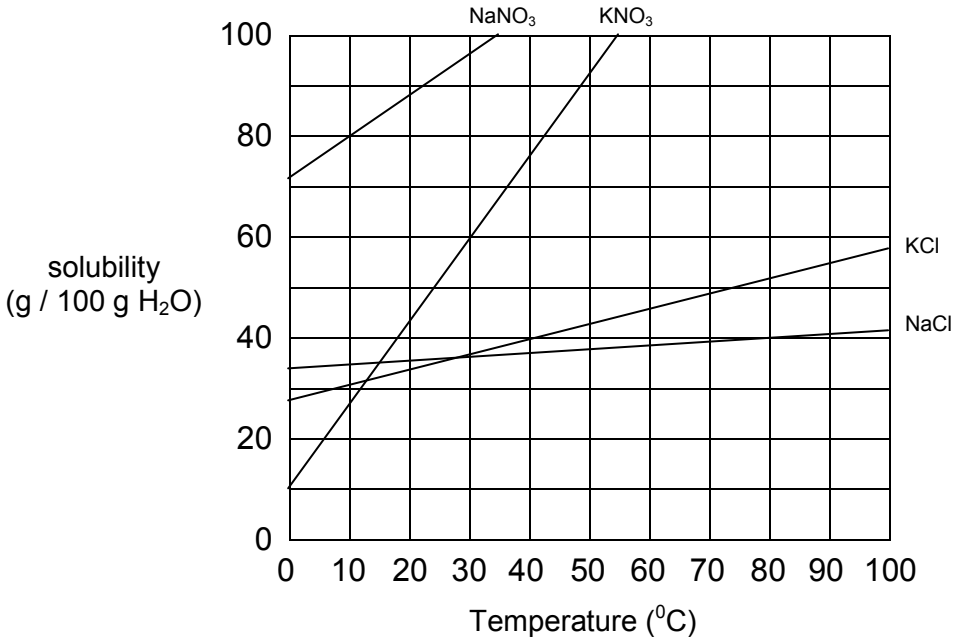
e) CH_2Cl_2 **polar**

f) nitrogen **nonpolar**

5) Explain the differences between covalent, polar covalent, and ionic compounds. (6 points)
Give two points for each of the following:
- **In covalent compounds, electrons are equally shared.**
- **In polar covalent compounds, the electrons spend more time near the more electronegative element.**
- **In ionic compounds, the electrons are completely transferred from the less electronegative element to the more electronegative element, resulting in the formation of ions that stick together.**

6) Soda is observed to go flat more quickly when warm than when cold. Explain this phenomenon. (4 points)
The solubility of gases decreases as the temperature of the solution increases.

7) Using the graph below, answer the following questions about the solubility of ionic compounds in water. (1 point each)



a) Which compound is most soluble at 45^0 C? **$NaNO_3$**

b) Which compound is least soluble at 35^0 C? **NaCl**

c) Which compound has the greatest range of solubilities over the temperature range shown? **KNO_3**

Suggested Grading Scale

33 = A+
30 – 32 = A
29 = B+
26 – 28 = B
25 = C+
23 – 24 = C
22 = D+
20 – 21 = D
< 20 = F

Colligative Properties Quiz

1) Write equations for the dissociation of the following compounds in water. (3 points each)

a) $NaOH_{(s)} \rightarrow$

b) $Na_2SO_{4(s)} \rightarrow$

c) $(NH_4)_3P_{(s)} \rightarrow$

d) $C_6H_{12}O_{6(s)} \rightarrow$

2) Circle the solution from each pair below that will have the highest boiling point. (1 point each)

0.5 M NaOH	1.5 M CsCl
1.0 M Na_2SO_4	2.0 M NH_4OH
3.0 M $Mg(OH)_2$	4.0 M MgS
1.75 M $Al(OH)_3$	2.75 M NaBr

3) Explain why the addition of salt to water raises the boiling point. (4 points)

4) Why doesn't the addition of 1.0 moles of a covalent compound to one liter of water lower the melting point as much as the addition of 1.0 moles of an ionic compound? (4 points)

Colligative Properties Quiz – Solutions

1) Write equations for the dissociation of the following compounds in water. (3 points each)
Grading: Give one point if they know the correct products, one point for having the correct coefficients in front of each product, and one point for remembering to put (aq) after each product.

a) $NaOH_{(s)} \rightarrow$ **$1\ Na_{(aq)}^{+1} + 1\ OH_{(aq)}^{-1}$**

b) $Na_2SO_{4(s)} \rightarrow$ **$2\ Na_{(aq)}^{+1} + 1\ SO_{4(aq)}^{-2}$**

c) $(NH_4)_3P_{(s)} \rightarrow$ **$3\ NH_{4(aq)}^{+1} + 1\ P_{(aq)}^{-3}$**

d) $C_6H_{12}O_{6(s)} \rightarrow$ **$1\ C_6H_{12}O_{6(aq)}$**

2) Circle the solution from each pair below that will have the highest boiling point. (1 point each)

0.5 M NaOH	**1.5 M CsCl**
1.0 M Na_2SO_4	**2.0 M NH_4OH**
3.0 M $Mg(OH)_2$	4.0 M MgS
1.75 M $Al(OH)_3$	2.75 M NaBr

3) Explain why the addition of salt to water raises the boiling point. (4 points)
Salt is nonvolatile, causing the vapor pressure of water to be less than if it wasn't present. Because boiling point is defined as the temperature at which the vapor pressure of the liquid is equal to atmospheric pressure, the boiling point is higher than the boiling point of pure water.

4) Why doesn't the addition of 1.0 moles of a covalent compound to one liter of water lower the melting point as much as the addition of 1.0 moles of an ionic compound? (4 points)
2 points for each of the following:
- **Ionic compounds break into component ions, making the effective particulate concentration greater than 1.0 M.**
- **Covalent compounds don't break apart, making the effective particulate concentration the same as the number of moles of the compound you added to the water.**

Suggested Grading Scale for the Colligative Properties Quiz

24 = A+
22 – 23 = A
21 = B+
19 – 20 = B
18 = C+
17 = C
16 = D+
14 – 15 = D
< 14 = F

Equilibria Quiz

1) Define the following terms: (2 points each)

- equilibrium:

- K_{sp}:

- reversible:

2) The Haber process for the manufacture of ammonia from hydrogen and nitrogen can be expressed by the following equation:

$$\mathbf{3\ H_{2(g)} + 1\ N_{2(g)} \rightleftharpoons 2\ NH_{3(g)}}$$

At equilibrium, the concentration of H_2 is 0.060 M, the concentration of N_2 is 0.020 M, and the concentration of NH_3 is 0.0021 M. Using this information, determine the equilibrium constant for the Haber process. (6 points)

3) The concentration of a saturated solution of $CaSO_4$ is 0.0084 M. Based on this information, find the solubility product of $CaSO_4$. (6 points)

4) State Le Châtelier's principle. (3 points)

5) Are the following double displacement reactions practical under normal conditions? Explain each answer in the space below. (4 points each)

a) $3\ NaF + Fe(OH)_3 \rightarrow NaOH + FeF_3$ $K_{sp}[Fe(OH)_3] = 2.64 \times 10^{-39}$

b) $CaBr_2 + 2\ NaOH \rightarrow 2\ NaBr + Ca(OH)_2$ $K_{sp}[Ca(OH)_2] = 4.68 \times 10^{-6}$

c) $MgF_2 + Ba(OH)_2 \rightarrow Mg(OH)_2 + BaF_2$ $K_{sp}[Mg(OH)_2] = 5.61 \times 10^{-12}$
$K_{sp}[BaF_2] = 1.84 \times 10^{-7}$

6) State the conditions of temperature and pressure that would shift the equilibrium to the product side. (2 points each)

a) $3\ H_{2(g)} + 1\ N_{2(g)} \rightarrow 2\ NH_{3(g)}$ $\Delta H = -49.16$ kJ/mol

b) $1\ CaCO_{3(s)} \rightarrow 1\ CaO_{(s)} + 1\ CO_{2(g)}$ $\Delta H = +178.3$ kJ/mol

Equilibria Quiz – Solutions

1) Define the following terms: (2 points each)

- equilibrium: **A reversible reaction where the rate of the forward and back reaction are the same.**
- K_{sp}: **Solubility product, equal to $(\Sigma[\text{products}]^x)/(\Sigma[\text{reagents}]^y)$**
- reversible: **A process that can proceed either from reagents to products or products to reagents.**

2) The Haber process for the manufacture of ammonia from hydrogen and nitrogen can be expressed by the following equation:

$$\mathbf{3\ H_{2(g)} + 1\ N_{2(g)} \rightleftharpoons 2\ NH_{3(g)}}$$

At equilibrium, the concentration of H_2 is 0.060 M, the concentration of N_2 is 0.020 M, and the concentration of NH_3 is 0.0021 M. Using this information, determine the equilibrium constant for the Haber process. (6 points)

$$\mathbf{K_{eq} = \frac{[NH_3]^2}{[H_2]^3\,[N_2]} = (0.0021)^2 / [(0.060)^2\,(0.020)] = 0.103}$$

3) The concentration of a saturated solution of $CaSO_4$ is 0.0084 M. Based on this information, find the solubility product of $CaSO_4$. (6 points)

$$\mathbf{K_{sp} = (Ca^{+2})(SO_4^{-2}) = (0.0084)(0.0084) = 7.1 \times 10^{-5}}$$

4) State Le Châtelier's principle. (3 points)
An equilibrium system that has been disturbed tends to correct itself to find a new equilibrium point that minimizes the initial disturbance.

5) Are the following double displacement reactions practical under normal conditions? Explain each answer in the space below. (4 points each)

a) $3\ NaF + Fe(OH)_3 \rightarrow NaOH + FeF_3$ $K_{sp}[Fe(OH)_3] = 2.64 \times 10^{-39}$
This reaction is not practical because one of the reagents is insoluble in water and both products are soluble in water.

b) $CaBr_2 + 2\ NaOH \rightarrow 2\ NaBr + Ca(OH)_2$ $K_{sp}[Ca(OH)_2] = 4.68 \times 10^{-6}$
This reaction is practical because both reagents are soluble in water and only one of the products is insoluble.

c) $MgF_2 + Ba(OH)_2 \rightarrow Mg(OH)_2 + BaF_2$ $K_{sp}[Mg(OH)_2] = 5.61 \times 10^{-12}$
$K_{sp}[BaF_2] = 1.84 \times 10^{-7}$
This reaction is not practical because both products are insoluble in water.

6) State the conditions of temperature and pressure that would shift the equilibrium to the product side. (2 points each)

a) $3\ H_{2(g)} + 1\ N_{2(g)} \rightarrow 2\ NH_{3(g)}$ $\Delta H = -49.16$ kJ/mol
High pressure, low temperature

b) $1\ CaCO_{3(s)} \rightarrow 1\ CaO_{(s)} + 1\ CO_{2(g)}$ $\Delta H = -178.3$ kJ/mol
Low pressure, low temperature

Suggested Grading Scale

37 = A+
33 – 36 = A
32 = B+
30 – 31 = B
28 – 29 = C+
26 – 27 = C
25 = D+
22 – 24 = D
< 24 = F