

**New Jersey Science League - Chemistry I Exam
January 2012**

Choose the answer that best completes the statements or questions below and fill in the appropriate response on the form. If you change an answer, be sure to completely erase your first choice. You may use the given periodic table and formula sheet as well as a calculator. On the formula sheets is a table of the activity series of the elements. Please PRINT your name, school, area, and which test you are taking onto the scan-tron.

1. Lord Kelvin (also known as J. J. Thomson) proposed a “plum pudding” model of an atom. Which statement describes this model correctly?
 - A. An atom is made up of a positively charged low density cloud with small negative charges called electrons embedded in it.
 - B. An atom is made up of negatively charged low density matter with small positive charges called positrons embedded in it.
 - C. An atom is a solid sphere of matter which cannot be further divided or destroyed.
 - D. An atom is made up of a tiny, very dense, positively charged nucleus that is surrounded by a swarm of very tiny, negatively charged electrons.

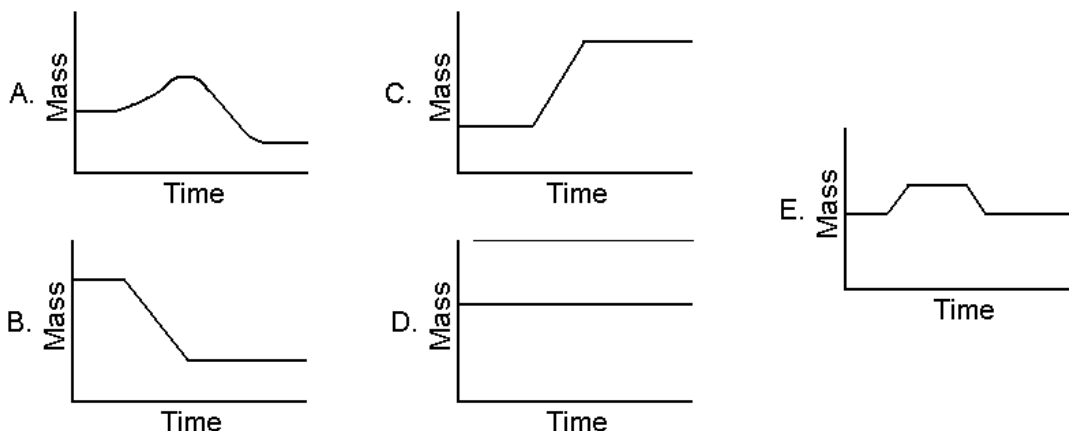
2. A difference between **mass** and **weight** is that
 - A. the weight of an object does not depend on the amount of material present.
 - B. weight is an intensive property while mass is an extensive property.
 - C. the mass of an object, but not its weight, is different on different planets.
 - D. the mass of an object is fixed, although its weight may vary with the gravitational force acting on it.

3. Only a physical change takes place in
 - A. producing water by burning hydrogen in air.
 - B. decomposing water into its elements by an electric current.
 - C. freezing of water.
 - D. changing water into hydrogen and oxygen by heating it to a very high temperature.

4. What is the best sequence of methods used to separate a mixture of salt, sand and iron filings recovering each ingredient?
 - A. magnetic extraction, dissolving in water, filtration, evaporation
 - B. evaporation, filtration, dissolving in water, magnetic extraction
 - C. dissolving in water, magnetic extraction, evaporation, filtration
 - D. magnetic extraction, evaporation, filtration, dissolving in water
 - E. filtration, magnetic extraction, dissolving in water, evaporation

5. When a sample of a pure substance is heated in a test tube, it gives off a reddish-brown colored gas and leaves a brown residue in the test tube. On the basis of this information, it is most reasonable to conclude that the pure substance is
 - A. a compound
 - B. an element
 - C. either an element or a compound
 - D. a solution

6. A piece of copper foil heated in a clean, uncovered crucible forms copper oxide. Which graph shows the change in mass of the crucible and its contents?



7. The following data was collected in a laboratory by measuring the volume of a sample of a gas at various temperatures at constant pressure. Subsequently the data was graphed.

Trial	Temperature ($^{\circ}\text{C}$)	Volume (cm^3)
1	25	100.0
2	30	101.7
3	35	103.4
4	40	105.0
5	45	106.7
6	50	108.4
7	55	110.1
8	60	111.7
9	65	113.4
10	70	115.1

Which of the following statements are **all true**?

- (1) The temperature values are placed on the horizontal axis.
 - (2) The volume measurements are placed on the horizontal axis.
 - (3) Volume is the dependent variable.
 - (4) The shape of the graph is a curve.
 - (5) The temperature and volume of a gas are directly proportional to each other.
- A. 2, 3, 4 B. 1, 3, 5 C. 3, 4, 5 D. 1, 2, 3 E. 1, 2, 4
8. Given the following types of reactions:
- (1) precipitation
 - (2) synthesis
 - (3) decomposition
 - (4) single replacement
 - (5) double replacement
- Which choices can both be applied to the following reaction:
 $\text{AgNO}_3(aq) + \text{NaCl}(aq) \rightarrow \text{AgCl}(s) + \text{NaNO}_3(aq)$
- A. (1) and (3) B. (3) and (4) C. (1) and (5) D. (2) and (5) E. (2) and (3)
9. Based on the “Metal Activity Series” table, which of the following reactions in water solutions will **NOT** happen spontaneously?
- A. $\text{Zn}(s) + 2 \text{AgNO}_3(aq) \rightarrow \text{Zn}(\text{NO}_3)_2(aq) + 2 \text{Ag}(s)$
 - B. $\text{Mg}(s) + \text{CuSO}_4(aq) \rightarrow \text{MgSO}_4(aq) + \text{Cu}(s)$
 - C. $\text{Fe}(s) + \text{PbSO}_4(aq) \rightarrow \text{FeSO}_4(aq) + \text{Pb}(s)$
 - D. $\text{Mn}(s) + \text{Ca}(\text{NO}_3)_2(aq) \rightarrow \text{Mn}(\text{NO}_3)_2(aq) + \text{Ca}(s)$

10. If ammonium molybdate is $(\text{NH}_4)_2\text{MoO}_4$, then
 A. cobalt (III) molybdate is Co_3MoO_4 B. potassium molybdate is KMoO_4
 C. aluminum molybdate is $\text{Al}_2(\text{MoO}_4)_3$ D. magnesium molybdate is $\text{Mg}_2(\text{MoO}_4)_3$

11. A student performed an experiment to determine the relative reactivity of metals by dipping each of the metals into solutions containing ions of the other metals, as well as into 1 M solution of hydrochloric acid. The table below represents the **incomplete** data collected.

	U^+ (aq)	V^{2+} (aq)	X^{2+} (aq)	Y^{2+} (aq)	Z^{2+} (aq)	H^+ (aq)
$\text{U}^0(\text{s})$		NR	NR		NR	NR
$\text{V}^0(\text{s})$	R		NR	NR	NR	NR
$\text{X}^0(\text{s})$	R	R			R	R
$\text{Y}^0(\text{s})$		R			NR	R
$\text{Z}^0(\text{s})$	R	R	NR	R		R

R = reaction observed NR = no reaction observed

The letters used are not the actual symbols for the metallic elements, except “H” that does represent hydrogen. Based on the available data, which choice represents the correct arrangement of metals (including Hydrogen) in the order of their **increasing** reactivity?

- A. H, U, Z, X, Y, V B. U, V, H, Y, Z, X
 C. Z, Y, V, H, X, U D. X, Z, Y, U, V, H
12. An aqueous solution of sodium carbonate is allowed to react with an aqueous solution of magnesium sulfate. Identify the solid in the balanced equation for this reaction.
 A. Na_2CO_3 B. MgSO_4 C. Na_2SO_4 D. MgCO_3
 E. There is no solid formed when the two solutions are mixed.
13. An aqueous solution of ammonium sulfate is allowed to react with an aqueous solution of lead (II) nitrate. Which of the following species can **all** be found in the **net ionic** equation for this reaction?
 A. $\text{NH}_4^+(\text{aq})$, $\text{SO}_4^{2-}(\text{aq})$, $\text{Pb}^{2+}(\text{aq})$ B. $\text{SO}_4^{2-}(\text{aq})$, $\text{Pb}^{2+}(\text{aq})$, $\text{Pb}(\text{SO}_4)(\text{s})$
 C. $\text{NH}_4^+(\text{aq})$, $\text{NO}_3^-(\text{aq})$, $\text{Pb}(\text{SO}_4)(\text{s})$ D. $\text{Pb}^{2+}(\text{aq})$, $\text{NO}_3^-(\text{aq})$, $\text{NH}_4\text{NO}_3(\text{s})$
 E. $\text{NO}_3^-(\text{aq})$, $\text{NH}_4^+(\text{aq})$, $\text{SO}_4^{2-}(\text{aq})$
14. In which set do all symbols have the same number of electrons?
 A. He^0 , Ne^0 , Ar^0 B. Li^+ , Ne^0 , Na^+ C. S^{2-} , Cl^- , Ar^0
 D. Cl^- , Ar^0 , Na^+ E. Ar^0 , K^+ , Mg^{2+}
15. Perform the mathematical operations below and express the result to the correct number of significant figures.
 $(2.0944 + 0.0003233 + 12.22) / (7.0001)$
 The correct answer is
 A. 14.314723 B. 2.045 C. 100.2 D. 2.0449 E. 14.31

16. Copper has a density of 8.96 g/cm^3 . If a cylinder of copper weighing 51.22 g is dropped into a graduated cylinder containing 20.00 mL of water, what will be the new water level?
 A. 5.72 mL B. 0.175 mL C. 14.28 mL D. 25.72 mL E. 34.68 mL
17. A sample of a sulfur-oxygen compound weighing 20.0 grams contains 10.0 grams of sulfur and 10.0 grams of oxygen. What is the ratio of sulfur atoms to oxygen atoms?
 A. 1 to 2 B. 32 to 16 C. 32 to 32 D. 16 to 4 E. 10.0 to 10.0
18. The fastest trains in the United Kingdom are capable of attaining speeds up to 225 km/h. What is the speed in miles per hour calculated to the correct number of significant figures? (Note: 1 mi = 5280 ft and 1 in = 2.54 cm)
 A. $2.57 \times 10^2 \text{ mi/h}$ B. $2.25 \times 10^2 \text{ mi/h}$ C. $3.00 \times 10^2 \text{ mi/h}$
 D. $1.39 \times 10^2 \text{ mi/h}$ E. $1.40 \times 10^2 \text{ mi/h}$
19. If 1.1×10^{24} molecules of a compound of carbon and hydrogen weigh 80. g, what is the formula of this compound?
 A. C_2H_2 B. C_2H_4 C. C_3H_6 D. CH_3CH_3 E. C_3H_8
20. A sample of an unknown element is found to contain four isotopes each of whose mass and abundance have been determined as follows:
 Isotope 1: 1.40% with a mass of 203.973 μ
 Isotope 2: 24.10% with a mass of 205.9745 μ
 Isotope 3: 22.10% with a mass of 206.9759 μ
 Isotope 4: 52.40% with a mass of 207.9766 μ
 Identify the unknown element.
 A. Th B. Pb C. Hg D. Bi E. At
21. What is the empirical formula for a compound composed of 15.8% carbon and 84.2% sulfur by mass?
 A. CS B. C_2S C. CS_2 D. CS_4 E. C_2S_3
22. A 98 gram sample of silver oxide is heated in an open container until all the oxygen has been driven off. What is the total mass of the silver remaining in the container?
 A. 32 grams B. 64 grams C. 86 grams D. 91 grams E. 105 grams
23. Upon analysis, the composition by mass of a compound was found to be 40.0% C, 6.7% H, and 53.3% O. Its mole mass was determined to be 180.1 g/mol. What is the molecular formula of this compound?
 A. CHO B. CH_2O C. $\text{C}_2\text{H}_4\text{O}_2$ D. $\text{C}_6\text{H}_{12}\text{O}_6$ E. $\text{C}_3\text{H}_6\text{O}_3$
24. One gram of an element **M** combines with 3.9 grams of chlorine. It forms an oxide with the formula M_2O_3 . What is the element?
 A. Li B. Fe C. Al D. B E. Au
25. Consider the following reaction: $2 \text{ A} + \text{ B} \rightarrow 3 \text{ C} + \text{ D}$. If 3.09 moles of A and 2.00 moles of B react to form 4.00 moles of C, what is the percent yield of this reaction?
 A. 86.3% B. 57.5% C. 43.1% D. 13.7% E. 100%

Chemistry I Answer Key
Date: Thursday January 12, 2012

1 A	6 C	11 B	16 D	21 C
2 D	7 B	12 D	17 A	22 D
3 C	8 C	13 B	18 E	23 D
4 A	9 D	14 C	19 E	24 C
5 A	10 C	15 B	20 B	25 A

CHEMISTRY 1 No AP or second year students in this category.

January Test has the following topics: scientific method, measurement, factor label conversions, properties, density, graphing, mixtures, compounds, formulas, mole, weight percent, chemical reactions, using the metal and non-metal activity series for writing chemical reactions, types of reactions, net ionic reactions, solubility rules, stoichiometry, atomic structure and history, but not electronic configuration.

February Test. quantum theory, electronic structure, orbital notation, dot notation, periodic behavior, plus January topics.

March Test. chemical bonding, molecular structure, simple isomers, intermolecular attractions, redox but not balancing redox equations, kinetic theory, solids, liquids, gases, gas laws, gas Stoichiometry, plus January and February topics.

April Test. solutions, reaction rates, chemical equilibrium, entropy, reaction spontaneity, K_{eq} , acids, bases, salts, net ionic equations, heat, heat in phase changes, thermo-chemistry, ΔH , Hess's law, plus January, February, and March topics.

Testing Dates for 2012

Thursday January 12, 2012, Thursday Feb 9, 2012;






Thursday March 8, 2012; *Thursday April 12, 2012

***The April 2011 exam can be changed based upon the Schools spring break.**
****The testing date for the April will be decided by each local area during the January exam. The date of the April exam should be a date that all schools in the area can attend. The April exam must be completed by April 30th. No area may take the April exam during the first week of April.**

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New Jersey Science League - Chemistry I Exam
February 2012

Choose the answer that best completes the statements or questions below and fill in the appropriate response on the form. If you change an answer, be sure to completely erase your first choice. You may use the given periodic table and formula sheet as well as a calculator. On the formula sheets is a table of the activity series of the elements. Please PRINT your name, school, area, and which test you are taking onto the scan-tron.

- Quantum mechanics explains or enables prediction of all of the following characteristics of atoms except:
 - probability of an electron being at a given location at any instant.
 - specific energy levels the electron can occupy.
 - the path or trajectory of the electrons.
 - the general symmetry of the electron orbitals.
 - frequencies of light absorbed or emitted by gaseous atoms.
- Five colors of light have five different wavelengths. The light with the highest **frequency** has a wavelength of
 - 3,100 Å
 - 4,000 Å
 - 5,400 Å
 - 6,200 Å
 - 7,000 Å
- Upon which does the size of a quantum of radiant energy directly depend?
 - speed
 - amplitude
 - frequency
 - wavelength
 - destructive interference
- How many completely filled orbitals are indicated by the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$?
 - 6
 - 26
 - 11
 - 15
 - 10
- Which of the following has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$?
 - Cr
 - Ca
 - Mn
 - Br
 - none of these
- The electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6$ represents all of the following except
 - Ti⁴⁺
 - Cr⁶⁺
 - S²⁻
 - V³⁺
 - Ca²⁺
- Which formula contains a positive ion whose electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$?
 - Ni(NO₃)₂
 - CoCl₂
 - Cu₂O
 - Fe₂(SO₄)₃
 - ZnS
- Which orbital notation correctly represents the outermost principal energy level of a phosphorus atom in the ground state.
 - s p

 - s p

 - s p

 - s p

 - s p


9. Given the following electron configuration for a neutral atom:
 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
 What is the number of orbitals containing unpaired electrons in this atom?
 A. 1 B. 2 C. 3 D. 4 E. 6
10. An atom "X" in the ground state contains a total of 5 electrons, 5 protons, and 5 neutrons. Which Lewis electron-dot diagram represents this atom?
 A. \ddot{X} B. $\ddot{X}\cdot$ C. $\cdot\ddot{X}\cdot$ D. $:\ddot{X}:$
11. Which is the correct Lewis electron-dot diagram for an atom of sulfur-33?
 A. \ddot{S} B. $\ddot{S}\cdot$ C. $\cdot\ddot{S}\cdot$ D. $:\ddot{S}:$
12. Of the following groups of three, the elements whose properties are most nearly alike are those having atomic numbers
 A. 1, 2, and 3 B. 14, 32, and 50 C. 5, 6, and 7 D. 1, 3, and 11 E. 16, 17, and 18
13. Which phrase best describes the periodic trend in properties of the elements when going from Group I-A to Group VII-A?
 A. increase in atomic volume B. decrease in electronegativity
 C. decrease in ionization energy D. decrease in metallic character
 E. increase in energy levels
14. In the series of alkali metals, Fr is the least electronegative. The **best** explanation of this phenomenon is:
 A. It has the greatest atomic number.
 B. It has more valence electrons than the others.
 C. Its incomplete valence shell is closest to the nucleus.
 D. Its valence electron is at the greatest distance from the nucleus.
 E. It has the greatest nuclear charge.
15. The trend for atomic radii to decrease from left to right across a period of the periodic table is ascribed to which of the following?
 A. Electrons attract each other, compressing the outer orbitals.
 B. Increasing nuclear mass has a gravitational effect, contracting the atomic size.
 C. Increasing nuclear charge offsets the repulsions of added electrons in the same shell.
 D. The statement is false; atomic radii increase across each period.
 E. Hund's rule and the Pauli exclusion principle combine to explain this phenomenon.
16. What does X stand for when the following chemical reaction is correctly balanced?
 aluminum oxide + hydrogen fluoride \rightarrow X + water.
 A. $3 H_2O$ B. $2 Al_2O_3$ C. Al_2F_3 D. AlF_3 E. $2 AlF_3$
17. Which nonmetal will react spontaneously with iodide ion, but not with chloride ion?
 A. F_2 B. Ne C. Br_2 D. I_2 (E) He

18. The reaction $\text{CH}_4(g) + 2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g) + \text{heat}$ indicates all of the following **except**:

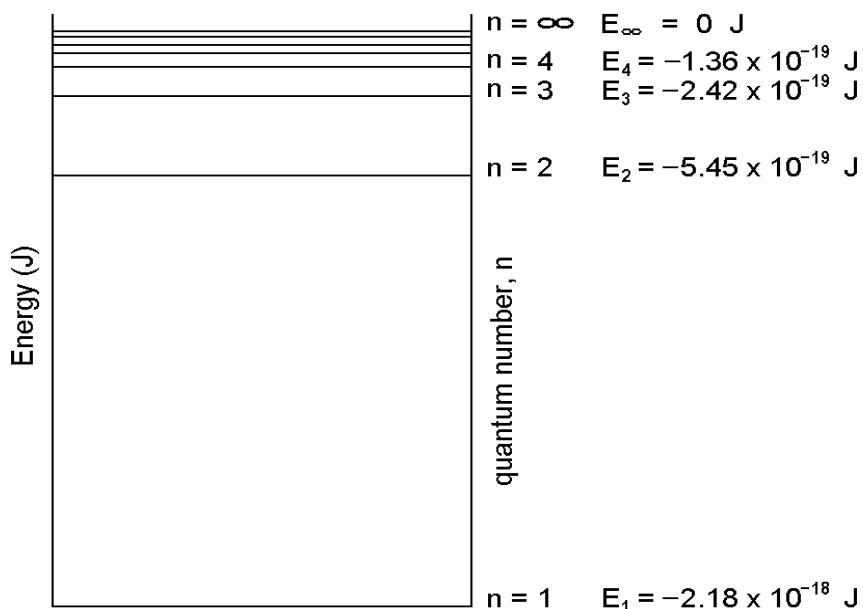
- A. The amounts of methane and oxygen used up per unit of time.
- B. Mass is conserved as methane is burned.
- C. Atoms are conserved as methane is burned.
- D. Oxygen is used up as methane is burned.
- E. The reaction is exothermic.

19. Separate samples of a solution of an unknown soluble ionic compound are treated with KCl, Na_2SO_4 , and NaOH. A precipitate forms only when Na_2SO_4 is added. Which cation could be present in the unknown soluble ionic compound?

- A. K^+
- B. Ba^{2+}
- C. Mg^{2+}
- D. Zn^{2+}
- E. Cu^{2+}

20. Given the diagram on the right, what is the wavelength of a photon emitted when an electron in a hydrogen atom jumps from $n = 4$ to $n = 2$?

- A. $4.08 \times 10^{-19} \text{ m}$
- B. $3.00 \times 10^{-8} \text{ m}$
- C. $5.63 \times 10^{-34} \text{ m}$
- D. $4.86 \times 10^{-7} \text{ m}$
- E. $2.18 \times 10^{-18} \text{ m}$



Energy Levels in the Bohr Atom

21. How many grams of sodium sulfate are produced in the double replacement reaction between 150. grams of hydrogen sulfate and 190. grams of sodium chloride?

- A. 190. g
- B. 217 g
- C. 230. g
- D. 333 g
- E. 461 g

22. An 80.0 grams sample of $\text{NaI} \cdot \text{H}_2\text{O}$ is heated in an open crucible until all the water has been driven off. What is the total mass of NaI remaining in the crucible?
 A. 8.6 grams B. 16.4 grams C. 22.0 grams D. 36.0 grams E. none of these
23. 10.00 grams of an unknown compound made up of carbon, hydrogen and oxygen is burned in excess oxygen producing 28.06 g of carbon dioxide and 5.74 grams of water vapor. What is the percent composition of the compound by mass?
 A. 27.3% carbon; 11.2% hydrogen; 61.6% oxygen
 B. 76.6% carbon; 6.42% hydrogen; 17.0% oxygen
 C. 28.1% carbon; 5.74% hydrogen; 66.2% oxygen
 D. 44.0% carbon; 2.02% hydrogen; 32.0% oxygen
 E. 66.0% carbon; 18.0% hydrogen; 38.0% oxygen
24. 1.42 grams of a pure compound, with the formula M_2SO_4 , was dissolved in water and treated with an excess of aqueous calcium chloride, resulting in the precipitation of all the sulfate ions as calcium sulfate. The precipitate was collected, dried, and found to weigh 1.36 g. What is the identity of the element "M"?
 A. Mg B. Na C. K D. Ag E. Ba
25. Galvanized steel used for roofing and air conditioning ducts is steel (mostly iron) plated with a thin layer of zinc on both sides. A student measured the length, the width, and the mass of a small rectangular sample of the galvanized steel. After removing the zinc coating (from both sides) by immersing the steel sample in 6 M hydrochloric acid, he measured its mass again. The collected data appears in the table below. What is the thickness of the zinc coating **on one side** of the galvanized steel sample? (Note: The density of iron is 7.86 g/cm^3 , and the density of zinc is 7.14 g/cm^3 .)

Length of galvanized steel sample	4.92 cm
Width of galvanized steel sample	3.78 cm
Mass of galvanized steel before acid	4.07 g
Mass of steel after acid	3.75 g

- A. $2.4 \times 10^{-3} \text{ cm}$ B. $4.2 \times 10^{-1} \text{ cm}$ C. $8.3 \times 10^{-1} \text{ cm}$ D. $1.2 \times 10^{-3} \text{ cm}$

Chemistry I Answer Key
Date: Thursday February 9, 2012

1 C	6 D	11 D	16 E	21 B
2 A	7 D	12 B	17 C	22 E
3 C	8 A	13 D	18 A	23 B
4 C	9 E	14 D	19 B	24 B
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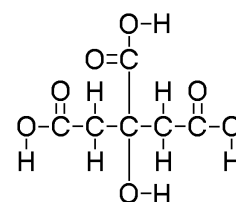
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New Jersey Science League - Chemistry I Exam
March 2012

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- The sharing of electrons in bond formation **always** involves
 - the formation of positive and negative ions.
 - lower energy content for bonded than for unbonded atoms.
 - the formation of polar molecules.
 - shared electrons being attracted more by one atom than another.
 - shared electrons being located equally near nuclei involved.
- A pure substance is relatively soft, melts at 113°C and does not conduct electricity in either the solid or liquid phase. The bonding in this substance is primarily
 - ionic
 - network
 - metallic
 - covalent
- The nitrogen-nitrogen triple bond involves
 - three sigma bonds.
 - one sigma and two pi bonds.
 - two sigma and one pi bond.
 - three pi bonds.
 - sp^3 hybridization.

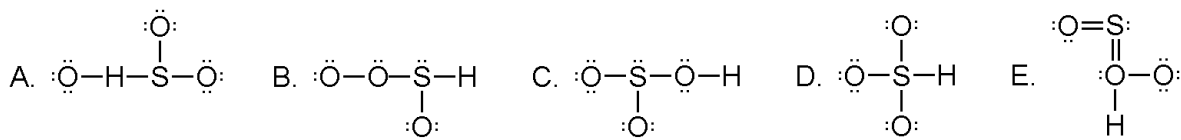
- The structure at the right represents a molecule of citric acid that is found in all citrus fruits. How many sigma and pi bonds does this molecule contain?



- 6 sigma and 7 pi bonds
 - 8 sigma and 7 pi bonds
 - 20 sigma and 3 pi bonds
 - 3 sigma and 20 pi bonds
 - 8 sigma and 6 pi bonds
- Acetylene ($\text{H}-\text{C}\equiv\text{C}-\text{H}$) torch is often used for welding and cutting due to the combustion of acetylene with oxygen that produces a flame of over 3300°C . What is the hybridization of each of the carbon atoms?
 - sp^1
 - sp^2
 - sp^3
 - sp^3d^1
 - sp^3d^2
 - Arrange the following set of molecules in terms of **unshared pairs** of electrons per molecule from the smallest number to the largest number:

I. NH_3	II. PCl_5	III. SF_6	IV. H_2O	V. CO_2	VI. CCl_4
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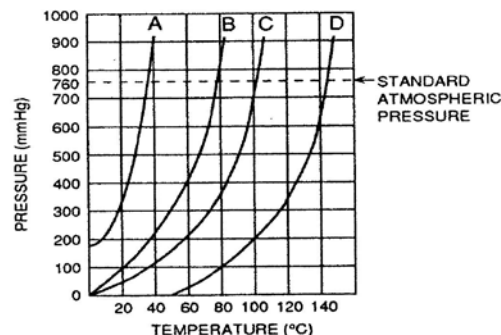
 - I, IV, V, VI, II, III
 - II, VI, I, III, IV, V
 - III, I, VI, II, V, IV
 - IV, V, II, I, VI, III
 - V, II, IV, VI, III, I
 - Which is a reasonable Lewis diagram representation of the hydrogen sulfite ion (HSO_3^-)?



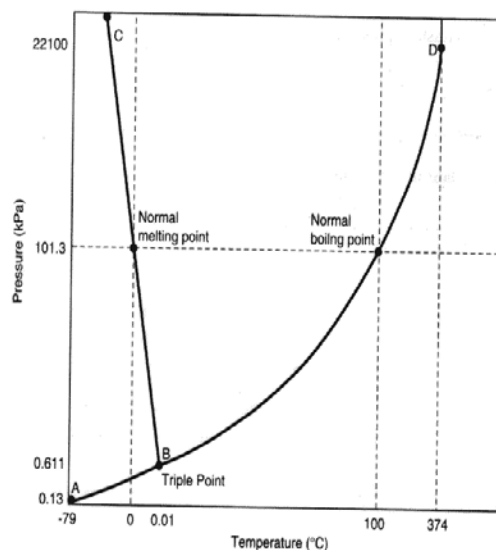
8. The geometry of the CO_2 molecule is best described as
 (A) trigonal planar (B) trigonal pyramidal (C) linear (D) bent (E) tetrahedral
9. Which choice correctly describes the hybridization of phosphorus in phosphorus pentachloride, and the molecular shape of PCl_5 molecule?
 (A) sp^3d ; linear (B) sp^3 ; tetrahedral
 (C) sp^3d ; trigonal bipyramidal (D) sp^3d^2 ; square planar
 (E) sp^3d^2 ; octahedral
10. Which compound is an isomer of the following compound:
- $$\begin{array}{c} \text{H} & \text{H} & \text{H} \\ | & | & | \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O} \\ | & | & | \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$$
- A. $\begin{array}{c} \text{H} & \text{H} \\ | & | \\ \text{H}-\text{C}-\text{C}-\text{O} \\ | & | \\ \text{H} & \text{H} & \text{H} \end{array}$ B. $\begin{array}{c} \text{H} & \text{H} & \text{H} \\ | & | & | \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ | & | & | \\ \text{H} & \text{H} & \text{O}-\text{H} \end{array}$ C. $\begin{array}{c} \text{H} & \text{H} & \text{H} \\ | & | & | \\ \text{O}-\text{C}-\text{C}-\text{C}-\text{O} \\ | & | & | \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ D. $\begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} \\ | & | & | & | \\ \text{H}-\text{C}-\text{O}-\text{C}-\text{C}-\text{C}-\text{H} \\ | & | & | & | \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$
- E. None of these
11. Which of the following compounds is incapable of hydrogen bond formation?
 A. H_2O B. $\text{C}_2\text{H}_5\text{OH}$ C. C_2H_6 D. NH_2OH
12. While methane (CH_4) is a gas at STP, carbon tetrachloride (CCl_4) is a liquid under the same conditions. This is primarily due to carbon tetrachloride's stronger
 (Note electronegativity values: H = 2.2; C = 2.6; Cl = 3.2)
 A. London forces between its molecules.
 B. dipole-dipole attractions between its molecules.
 C. hydrogen bonds between its molecules.
 D. dipole-ion attractions within its molecules.
 E. polarity of covalent bonds within its molecules.
13. Which statement concerning this equation is true? $\text{TiCl}_4 + 2 \text{Mg} \rightarrow 2 \text{MgCl}_2 + \text{Ti}$
 A. Mg is the oxidizing agent. B. TiCl_4 is the reducing agent.
 C. Ti accepts electrons from Mg. D. MgCl_2 is a molecular substance
14. A student made the following observations in the laboratory:
 (1) Clean metal **Q** did not react with a 1 molar solution of $\text{T}(\text{NO}_3)_2$.
 (2) Clean metal **T** reacted with a 1 molar ZNO_3 solution, and crystals of **Z** metal appeared.
 (3) Clean metal **Z** did not react with a 1 molar solution of $\text{Q}(\text{NO}_3)_2$.
 The order of decreasing strength as reducing agents of the three metals is shown to be:
 A. **Q, T, Z** B. **Q, Z, T** C. **T, Z, Q** D. **T, Q, Z** E. **Z, T, Q**
15. What is the apparent charge on the manganese atom in the permanganate ion MnO_4^-
 A. +2 B. +3 C. +4 D. +7 E. +8

16. Two flexible containers for gases are at the same temperature and pressure. One holds 0.50 gram of hydrogen and the other holds 8.0 grams of oxygen. Which of the following statements regarding these gas samples is **FALSE**?
- The number of molecules in the hydrogen container is the same as the number of molecules in the oxygen container.
 - The volume of the hydrogen container is the same as the volume of the hydrogen container.
 - The density of the hydrogen sample is less than that of the oxygen sample.
 - The average kinetic energy of the hydrogen molecules is the same as the average kinetic energy of the oxygen molecules.
 - The average speed of the hydrogen molecules is the same as the average speed of the oxygen molecules.

17. The vapor pressure curves of four liquids, A, B, C and D are shown on the graph at the right. Which liquid has the strongest intermolecular attractions?
- liquid A
 - liquid B
 - liquid C
 - liquid D
 - All four liquids have the same intermolecular attractions.



18. Given the phase diagram for water on the right. Which phase, or phases, of water can exist at 50.0 kPa of pressure and a temperature of -40°C ?
- solid, only
 - liquid, only
 - gas only
 - solid and liquid, only
 - solid, liquid and gas



19. When a sample of oxygen gas in a closed container of constant volume is heated until its absolute (Kelvin) temperature is doubled, which of the following is also doubled?
- the density of the gas
 - the average velocity of the gas molecules
 - the pressure of the gas
 - the number of molecules per cm^3
 - the potential energy of the molecules

20. Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $\text{NaN}_3(s)$. The decomposition reaction produces $\text{N}_2(g)$, as well as $\text{Na}(s)$, according to the balanced equation: $2 \text{NaN}_3(s) \rightarrow 2 \text{Na}(s) + 3 \text{N}_2(g)$. When the air bag inflates, the nitrogen gas is at a pressure of 1.3 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. The volume of this nitrogen gas at STP would be
A. 267 L B. 47 L C. 3 L D. 52 L E. 44 L
21. A gas mixture in a rigid container is made up of twice as many moles of O_2 as N_2 . Addition of 0.200 mole of argon to this mixture increases the pressure from 0.800 atm to 1.200 atm. How many moles of O_2 are in the mixture?
A. 0.267 mol B. 0.178 mol C. 0.555 mol D. 0.200 mol E. 0.0750 mol
22. The reaction between kerosene and fuming HNO_3 is used as a rocket fuel. The balanced reaction is $\text{C}_{14}\text{H}_{30}(l) + 86 \text{HNO}_3(l) \rightarrow 14 \text{CO}_2(g) + 86 \text{NO}_2(g) + 58 \text{H}_2\text{O}(g)$
How many **liters of products** at STP would be formed from one mole of kerosene?
A. 158 liters B. 191 liters C. 219 liters D. 1,910 liters E. 3,540 liters
23. At standard conditions, what is the maximum volume of ethane gas (C_2H_6) that could be produced from the union of 440. liters of hydrogen gas and 150. grams of carbon?
A. 67.2 liters B. 132 liters C. 140. liters D. 146.6 liters E. 150.5 liters
24. What is the density of nitrogen dioxide, NO_2 , at standard conditions in grams per liter?
A. 0.49 g/L B. 0.94 g/L C. 1.77 g/L D. 1.89 g/L E. 2.05 g/L
25. What is the molecular mass of YZ_2 , if 300. mL at STP of this gas weighs 0.855 gram?
A. 32.6 μ B. 44.1 μ C. 56.9 μ D. 63.8 μ E. 88.2 μ

Chemistry I Answer Key
Date: Thursday March 8, 2012

1 B	6 A	11 C	16 E	21 A
2 D	7 C	12 A	17 D	22 E
3 B	8 C	13 C	18 A	23 C
4 C	9 C	14 D	19 C	24 E
5 A	10 B	15 D	20 B	25 D

CHEMISTRY 1 No AP or second year students in this category.

January Test has the following topics: scientific method, measurement, factor label conversions, properties, density, heat, heat in phase changes, graphing, mixtures, compounds, formulas, mole, weight percent, chemical reactions, using the metal and non-metal activity series for writing chemical reactions, Stoichiometry, atomic structure and history, but not electronic configuration.

February Test. Quantum Theory, Electronic structure, orbital notation, dot notation, periodic behavior, plus January topics.

March Test. Chemical bonding, molecular structure, simple isomers, intermolecular attractions, redox but not balancing redox equations, kinetic theory, solids, liquids, gases, gas laws, gas stoichiometry, plus January and February topics.

April Test. solutions, reaction rates, chemical equilibrium, K_{eq} , acids, bases, salts, net ionic equations, thermo-chemistry, ΔH , Hess's law, plus January, February, and March topics.

Testing Dates for 2012

Thursday March 8, 2012; *Thursday April 12, 2012

*The April 2012 exam can be changed based upon the School's spring break.

New Jersey Science League

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Testing Dates 2013

Thursday January 10, 2013, Thursday Feb 14, 2013;

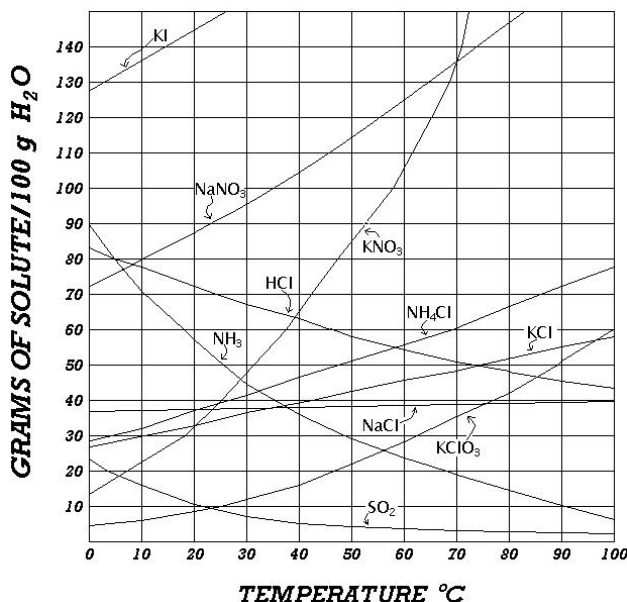
Thursday March 14, 2013; *Thursday April 11, 2013

*The April 2013 exam can be changed based upon the School's spring break.

New Jersey Science League - Chemistry I Exam
April 2012

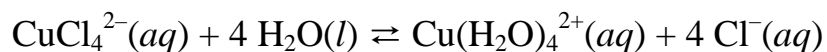
Choose the answer that best completes the statements or questions below and fill in the appropriate response on the form. If you change an answer, be sure to completely erase your first choice. You may use the given periodic table, formula sheet, as well as a calculator. On the formula sheets is a table of the activity series of the elements. Please PRINT your name, school, area, and which test you are taking onto the scan-tron.

1. According to the solubility curves at the right, which substance's solubility **increases** the most between 40 °C and 50 °C?
- HCl
 - NH₄Cl
 - NaCl
 - KClO₃
 - SO₂



2. Which gas can be **least** readily collected by the displacement of water from a container?
- H₂
 - N₂
 - O₂
 - NH₃
 - CO₂
3. Which 0.2 molal aqueous solution will have the smallest freezing point change?
- 0.2 molal CaCl₂
 - 0.2 molal NaCl
 - 0.2 molal CH₃OH
 - 0.2 molal H₃PO₄
 - 0.2 molal MgSO₄.
4. Given the following system at equilibrium involving decomposition of the gas arsine, AsH₃:
 $2 \text{AsH}_3(g) \rightleftharpoons 2 \text{As}(s) + 3 \text{H}_2(g)$. Which is the correct representation of the equilibrium constant expression for this system?
- $K_{\text{eq}} = \frac{[\text{As}]^2 [\text{H}_2]^3}{[\text{AsH}_3]^2}$
 - $K_{\text{eq}} = \frac{[\text{AsH}_3]^2}{[\text{As}]^2 [\text{H}_2]^3}$
 - $K_{\text{eq}} = \frac{[\text{H}_2]^3}{[\text{AsH}_3]^2}$
 - $K_{\text{eq}} = [\text{As}]^2 [\text{H}_2]^3$
 - $K_{\text{eq}} = \frac{1}{[\text{As}]^2 [\text{H}_2]^3}$
5. In the reaction $\text{HC}_2\text{H}_3\text{O}_2(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{C}_2\text{H}_3\text{O}_2^-(aq)$, the addition of solid sodium acetate (NaC₂H₃O₂) results in a **decrease** in the concentration of
- Na⁺(aq)
 - C₂H₃O₂⁻(aq)
 - H₃O⁺(aq)
 - HC₂H₃O₂(aq)
 - H₂O(l)

6. When a solution of copper (II) chloride was prepared, an equilibrium system was produced according to the equation below that included two different copper complex ions:



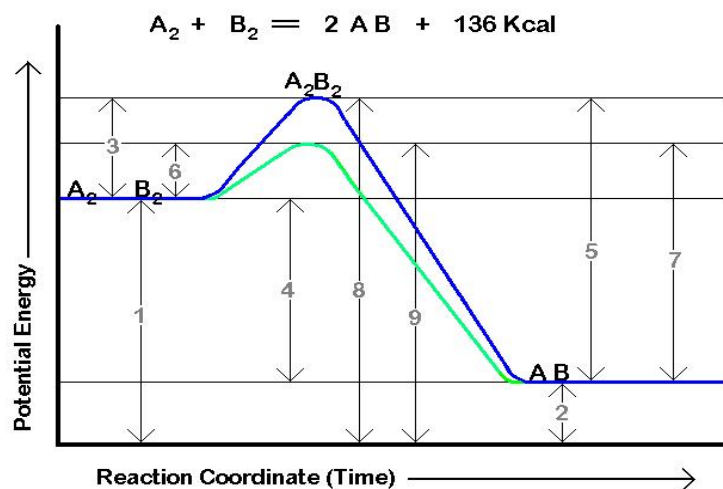
The colors of the copper ions were as follows: $\text{CuCl}_4^{2-}(aq)$ was green, while $\text{Cu}(\text{H}_2\text{O})_4^{2+}(aq)$ was blue. The rest water molecules and chloride ions were colorless. The overall solution was blue-green color when the experiment began. When a test tube holding this solution was placed into a hot water bath, the mixture became **greener** in color. Based on this observation, which of the statements below is true about this equilibrium system?

- A. The forward reaction is endothermic.
 B. The reverse reaction is exothermic.
 C. Adding heat causes the equilibrium to shift to the right.
 D. Adding heat causes the equilibrium to shift to the left.
 E. Taking away heat causes the equilibrium to shift to the left.
7. The equilibrium constant for a chemical reaction has the value of 1.5. This value means:
 A. Products are slightly favored at equilibrium
 B. Reactants are slightly favored at equilibrium
 C. The amounts of products and reactants are equal at equilibrium
 D. The value by itself has no significance to an equilibrium equation
8. Which statement is true regarding the following chemical reaction?
 $\text{H}_2(g) + \text{Cl}_2(g) \rightarrow 2 \text{HCl}(g) + 44.2 \text{ kcal}$
 A. ΔH of formation for HCl is equal to -44.2 kcal/mol
 B. ΔH of formation for HCl is equal to -22.1 kcal/mol
 C. ΔH of formation for HCl is equal to $+22.1 \text{ kcal/mol}$
 D. ΔH of formation for HCl is equal to $+44.2 \text{ kcal/mol}$
 E. The heat content of the products is greater than the heat content of the reactants.

9. Consider the Potential Energy Diagram below:

Which double pointed arrow represents the heat of reaction (ΔH) for the **catalyzed reverse** reaction?

- A. 6
 B. 3
 C. 2
 D. 4
 E. 5



10. Which forward reaction shows an increase in entropy?
 The entropy of the system
 A. $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$
 B. $2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(l)$
 C. $\text{NaF}(s) + \text{KI}(s) \rightarrow \text{NaI}(s) + \text{KF}(s)$
 D. $\text{H}_2(g) + \text{CuO}(s) \rightarrow \text{H}_2\text{O}(l) + \text{Cu}(s)$
 E. $\text{HCl}(g) + \text{NH}_3(g) \rightarrow \text{NH}_4\text{Cl}(s)$

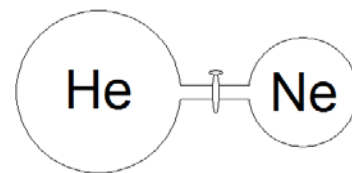
11. Which pair of changes insures that a chemical system undergoes a spontaneous reaction?
 A. a decrease in enthalpy and entropy B. an increase in enthalpy and a decrease in entropy
 C. an increase in enthalpy and entropy D. an increase in enthalpy with entropy constant
 E. a decrease in enthalpy and an increase in entropy
12. A 0.1 molal aqueous salt solution has a freezing point of $-0.74\text{ }^{\circ}\text{C}$. The freezing point constant for water is $1.86\text{ }^{\circ}\text{C/molal}$. Assuming the salt solution to be completely ionized, then which formula is possible for the salt? M is a metal, while X is a nonmetal.
 A. MX B. MX_2 C. M_2X_3 D. MX_4 E. M_3X .
13. Ionic compounds in the solid state at room temperature are generally characterized by
 A. ability to conduct an electric current. B. high vapor pressure
 C. solubility in polar solvents D. solubility in nonpolar solvents
 E. low melting points.
14. In the reaction below $\Delta H - T\Delta S$ is equal to 0. Which change will cause $\Delta H - T\Delta S$ to no longer = 0? All full credit
- $$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g}) + \text{kJ}$$
- A. removal of $\text{HI}(\text{g})$ B. addition of $\text{HI}(\text{g})$ C. addition of $\text{H}_2(\text{g})$
 D. increasing the pressure E. decreasing the temperature
15. Given the following system at equilibrium: $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$. Which species **both** act as Brönsted-Lowry acids?
 A. NH_3 and H_2O B. NH_4^+ and OH^- C. NH_3 and NH_4^+
 D. H_2O and NH_4^+ E. NH_3 and NH_4^+
16. A solution has a pH value of 3.25. Which statement is NOT true about this solution?
 A. $[\text{H}_3\text{O}^+] > [\text{OH}^-]$ B. $[\text{H}_3\text{O}^+] = [\text{OH}^-]$ C. $[\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$ D. $\text{pH} + \text{pOH} = 14$
 E. This solution is an acid.
17. Given the formulas of several salts:
 (1) NaCl (2) NH_4Cl , (3) K_2CO_3 (4) $\text{Zn}(\text{NO}_3)_2$ (5) $\text{NaC}_2\text{H}_3\text{O}_2$ (6) LiBr .
 Which salts' solutions would turn phenolphthalein pink?
 A. 1 and 2 B. 3 and 4 C. 5 and 6 D. 2 and 4 E. 3 and 5
18. A slightly soluble salt has the formula M_2S where M represents a metal and S represents a non-metal. If "x" represents the molar solubility of M_2S , then which expression would represent the K_{sp} of this salt?
 A. $4x^3$ B. $x^3/4$ C. $4x^2$ D. $(2x)^3$ E. x^3
19. More heat is derived from cooling one gram of steam at 100°C to water at 50°C , than from cooling one gram of liquid water from 100°C to 50°C , because
 A. Water is a poor thermal conductor.
 B. Steam is hotter than the liquid water.
 C. The steam occupies a greater volume than the liquid water.
 D. The density of water is greater than that of steam.
 E. The heat of condensation is evolved.

20. The data given in the table below were collected for the reaction: $A + B \rightarrow D + E$. What is the overall reaction order?

Trial	[A] (mol/L)	[B] (mol/L)	Initial Rate (mol/L·min)
1	0.10	0.20	200
2	0.10	0.10	50
3	0.30	0.10	150

- A. First B. Second C. Third D. Fourth E. Zero
21. Given the reaction $2 \text{Al}(s) + 3/2 \text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s)$; $\Delta H = -1673.6 \text{ kJ/mol}$. How much heat will be given off by the reaction of 27.0 grams of aluminum reacting with excess oxygen?
A. 418 kJ B. 837 kJ C. 1260 kJ D. 1670 kJ E. 3350 kJ
22. Given the following data:
 $2 \text{ClF} + \text{O}_2 \rightarrow \text{Cl}_2\text{O} + \text{F}_2\text{O}$ $\Delta H = + 167.4 \text{ kJ}$
 $2\text{ClF}_3 + 2\text{O}_2 \rightarrow \text{Cl}_2\text{O} + 3 \text{F}_2\text{O}$ $\Delta H = + 341.4 \text{ kJ}$
 $2 \text{F}_2 + \text{O}_2 \rightarrow 2 \text{F}_2\text{O}$ $\Delta H = - 43.4 \text{ kJ}$
 Calculate ΔH for the reaction: $\text{ClF}_3 \rightarrow \text{ClF} + \text{F}_2$
 A. +217.5 kJ B. +130.2 kJ C. +108.7 kJ D. -217.5 kJ (E) +217.4 kJ
23. You are given 3 aqueous solutions that are 0.1M for each. Substance A is a strong electrolyte, substance B is a weak electrolyte and substance C is a non-electrolyte. How could you test the “electrolyte” statements experimentally?
 A. Test each with litmus paper. B. React each solution with zinc
 C. Test the electrical conductivity of each D. Test the action of each with copper wire
 E. Test each with cobalt chloride paper.
24. Commercially produced carbonated beverages are mostly solutions of fructose ($\text{C}_6\text{H}_{12}\text{O}_6$) in water with small amounts of other flavorings added. A student experimentally found the molar concentration of fructose in a can of clear colorless soda using a refractometer and a calibration curve to be 0.626 M. If the density of the soda was 1.04 g/mL, what was the percentage concentration by mass of fructose in a 12 oz (355 mL) can? (Assume that other ingredients are negligible.)
 A. 40.0% B. 7.41% C. 62.6% D. 10.8% E. 22.2%

25. The diagram at the right represents a 5.00-Liter bulb and a 3.00-Liter bulb are attached by a closed stopcock. The larger bulb contains helium gas at 540. mm of Hg, while the smaller bulb contains neon gas at 320. mm of Hg. What is the pressure in the larger bulb after the stopcock is opened and equilibrium is achieved with no change in temperature?



- A. 540. mm of Hg B. 458 mm of Hg C. 338 mm of Hg
 D. 320. mm of Hg E. 120. mm of Hg

Chemistry I Answer Key
Date: Thursday April 12, 2012

1 D	6 D	11 E	16 B & C	21 B
2 D	7 A	12 E	17 E	22 C
3 C	8 B	13 C	18 A	23 C
4 C	9 D	14 E All full credit	19 E	24 D
5 C All full credit	10 A	15 D	20 C	25 B

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Testing Dates 2013

**Thursday January 10, 2013, Thursday Feb 14, 2013;
Thursday March 14, 2013; *Thursday April 11, 2013**

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**Please review the topics above. Considering that the last test is in April
which topics would you leave out?**

Please send your comments to newjsl@ptd.net