New Jersey Science League - Chemistry I Exam
January 2014

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. Iron (III) oxide is the color of rust. This statement is
   A. a correct definition of a chemical term or expression, either in terms of experimental behavior or of sound scientific theory.
   B. a specific experimental fact that is not related to any scientific law.
   C. a false statement of a law, theory, or definition.
   D. a scientific law expressing the directly observable results of many different experiments.
   E. a scientific theory, which, while it cannot be directly measured or observed, is in accord with and explains the results of experiments.

2. Water is poured into a beaker and placed on top of a hot plate. The water's temperature rises over several minutes. Eventually, bubbles appear at the bottom of the beaker and rise to the top of the liquid. More bubbles begin to appear all over the volume of the water as it starts to boil. After boiling continues for several minutes, which statement or statements below is/are completely true concerning the above process?
   1. Boiling of water is a chemical change because liquid changes into gas.
   2. Boiling of water is a physical change because liquid water is the same substance as water vapor.
   3. The bubbles that form when water boils are made up of a mixture of hydrogen and oxygen gases only.
   4. The bubbles that form when water boils for several minutes contain water vapor only.

   A. 1, only B. 2 and 4, only C. 1 and 3, only D. 3, only E. 1 and 4, only

3. A hot air balloon rises. This can be **best** explained by the statement:
   A. Air pressure inside the balloon is greater than the air pressure outside the balloon.
   B. Air pressure outside the balloon is greater than the air pressure inside the balloon.
   C. Hot air inside the balloon is less dense than cold air outside the balloon.
   D. Cold air outside the balloon is less dense than warm air inside the balloon.

4. Which of the following is a **mixture**?
   A. NaCl(*s*) B. NaCl(*l*) C. NaCl(*g*) D. NaCl(*aq*)

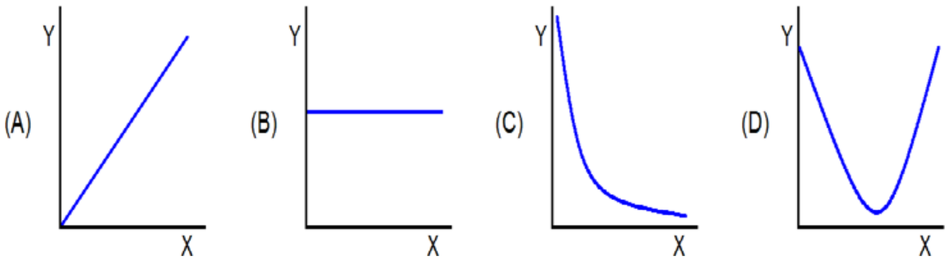
5. Which is characteristic of a **compound**?
   A. It can consist of a single element. B. It can be decomposed by a physical change.
   C. It is homogeneous. D. Its chemical composition can be varied.

6. Silver hydrogen phosphate has the formula Ag_2HPO_4. What is the formula for iron (III) hydrogen phosphate?
   A. Fe_2HPO_4 B. $Fe_3(HPO_4)_2$ C. $Fe_2(HPO_4)_3$
   D. $Fe(HPO_4)_3$ E. $Fe(HPO_4)_2$

7. The following data was taken during an experiment in a laboratory, with "X" being the independent variable, and "Y" being the dependent variable:

X	0.53 atm	1.03 atm	1.53 atm	2.03 atm	2.53 atm
Y	33.21 L	17.09 L	11.50 L	8.67 L	6.96 L

Which of the following most closely resembles the graph based on the above data?



(E) none of these

8. Which set of coefficients correctly balances the chemical equation:
silicon dioxide + carbon + calcium phosphate → calcium silicate ($CaSiO_3$) + phosphorus + carbon monoxide
A. 2,3,5,5,3,1 B. 1,3,5,2,3,5 C. 2,3,5,1,3,5 D. 3,5,1,3,2,5 E. 2,3,4,3,2,4

9. No reaction will take place when a solution of copper (II) sulfate is placed in a container made of
A. silver B. iron C. lead D. zinc E. tin

10. Classify the following reaction: $2\,Mg(s) + O_2(g) \rightarrow 2\,MgO(s)$
A. decomposition, only B. combustion, only C. synthesis, only
D. oxidation-reduction, only E. oxidation-reduction, combustion, and synthesis, only

11. Which of the following equations represents **both** a single replacement as well as an oxidation-reduction reaction?
A. $2\,Zn(s) + O_2(g) \rightarrow 2\,ZnO(s)$

B. $Mg(s) + H_2SO_4(aq) \rightarrow H_2(g) + MgSO_4(aq)$

C. $HNO_3(aq) + KOH(aq) \rightarrow H_2O(l) + KNO_3(aq)$

D. $CuCl_2(aq) + 2\,LiBr(aq) \rightarrow CuBr_2(s) + 2\,LiCl(aq)$

E. $Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(g)$

12. Which assumptions of Dalton's atomic theory had to be revised or discarded **because of the existence of stable isotopes**?
1. The ultimate particles of matter are the atoms of elements, which are indivisible and indestructible.
2. All atoms of a given element are alike in all respects.
3. The atoms of different elements differ in one or more properties.
4. Compounds are formed by combination of different kinds of atoms.

A. 1 only B. 2 only C. 3 only D. 4 only E. 1 and 2 only

13. Which particle most likely consists of 13 protons, 14 neutrons, and 10 electrons?
A. a neon atom B. a sodium atom C. an aluminum ion
D. a silicon atom E. a phosphide ion

14. What do these have in common? ^{20}Ne $^{19}F^-$ $^{24}Mg^{2+}$
A. the same number of protons B. the same number of neutrons
C. the same number of electrons D. the same number of nucleons
E. the same charge

15. During the late 18th century, French chemist Antoine Lavoisier, with the help of his wife Marie-Anne, conducted several experiments involving heating substances in sealed containers with air inside them. Chemical changes were observed within the containers during the heating process, and the records of masses were kept before and after heating. The results of these experiments led to the formulation of the Law of
A. Conservation of Mass B. Conservation of Energy C. Definite Proportions
D. Partial Pressures E. Chemical Equilibrium

16. The mass in **grams** of 1 molecule of water is
A. 2.99×10^{-23} g B. 6.02×10^{-23} g C. 2.99×10^{-23} g
D. 1.80×10^{-24} g E. 1.00×10^{-23} g

17. A one Liter graduated cylinder has water added to it until the cylinder is completely filled. The water was then added to a 2.0 Liter cylinder and measured to be 1350 mL. The density of water is 1.0 g/mL. On the one Liter cylinder, the height from the one Liter mark to the top of the cylinder is 5.25 cm. Determine the radius of the one Liter cylinder to the correct number of significant figures.
A. 17.8 cm B. 4.17 cm C. 1.5 cm D. 4.6 cm E. 4.22 cm

18. What volume of lead (density =11.3 g/cm^3) has the same mass as 100. cm^3 of a piece of red wood (density = 0.38 g/cm^3)?
A. 11.3 cm^3 B. 3.4 cm^3 C. 38 cm^3 D. 29.7 cm^3 E. 11.7 cm^3

19. The density of carbon dioxide is 1.977 g/L at 0^{o}C and 1 atm pressure. How many moles are there in one Liter of the pure carbon dioxide?
A. 8.701×10^{-1} mol B. 4.401×10^{-1} mol C. 1.977×10^{0} mol
D. 2.226×10^{-2} mol E. 4.492×10^{-2} mol

20. In an experiment, the **mole mass** of magnesium was determined to be 24.7 g/mol. Compared to the accepted value of 24.3 g/mol, the **percent error** for this determination was about

A. 0.40% B. 1.65% C. 24.7% D. 98.4% E. none of these

21. Sulfur reacts with oxygen according to the following equation: $S(s) + O_2(l) \rightarrow SO_2(g)$ When 11.0 grams of sulfur reacts with excess oxygen, 19.7 g of SO_2 is collected. What is the percent yield of sulfur dioxide in this reaction?

A. 55.8% B. 89.6% C. 64.2% D. 100% E. 111%

22. A sheet of pure copper is 15.92 cm long and 4.28 cm wide. Its mass is 9.4 grams. If the density of copper is 8.96 g/cm^3, what is the **thickness** of the copper sheet calculated to the **correct number of significant figures**?

A. 0.71 cm B. 1.54×10^{-2} cm C. 0.015 cm D. 0.574 cm E. 6.495×10^{-2} cm

23. A compound contains 20.% hydrogen and 80.% carbon by mass. What is the empirical formula for this compound?

A. CH B. CH_2 C. CH_3 D. CH_4 E. C_4H

24. If 1.5 grams of N_2 reacts with 1.0 grams of H_2, how many grams of NH_3 may be produced according to the following equation:

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

A. 1.8 g B. 5.6 g C. 2.5 g D. 0.54 g E. 3.0 g

25. Consider a piece of gold jewelry that weighs 9.55 g and has a volume of 0.665 cm^3 . The jewelry contains only gold and silver, which have densities of 19.3 g/cm^3 and 10.5 g/cm^3, respectively. If the total volume of the jewelry is the sum of the volumes of the gold and silver that it contains, calculate the percentage of gold and silver (by mass) in the jewelry.

A. 41.0% Au and 59.0% Ag B. 59.0% Au and 41.0% Ag

C. 29.8% Au and 70.2% Ag D. 70.2% Au and 29.8% Ag

Periodic Table and Chemistry Formulas
Updated

Periodic Table of the Elements
[amu to 5 significant digits]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116	117	118

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	Lanthanide Series
89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	Actinide Series

IQUIDS, SOLUTIONS

PV = nRT

$\frac{(P + n^2a)(V-nb)}{V^2} = nRT$

$P_A = P_{total} \bullet X_A$

$P_{total} = P_A + P_B + P_C +$

$n = \frac{m}{M}$

Kelvin = $^oC + 273$

$P_1V_1 = P_2V_2$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$d = \frac{m}{V}$

$u_{rms} = \sqrt{\frac{3kt}{m}} = \sqrt{\frac{3RT}{M}}$

$KE_{per\ molecule} = \frac{mv^2}{2}$

$KE_{per\ mole} = \frac{3RT}{2}$

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

M, molarity = $\frac{\text{moles solute}}{\text{liter of solution}}$

molality = $\frac{\text{moles of solute}}{\text{kg of solvent}}$

$\Delta T_f = iK_f \bullet$ molality

$\Delta T_b = iK_b \bullet$ molality

$\pi = \frac{nRTi}{V}$

P = pressure
V = volume
T = Temperature
n = number of moles
d = density
m = mass
v = velocity
where $X_A = \frac{\text{moles A}}{\text{total moles}}$

u_{rms} = root-mean-square-root
KE = Kinetic energy
r = rate of effusion
M = Molar mass
π = osmotic pressure
i = van't Hoff factor
K_f = molal freezing point constant
K_b = molal boiling point constant
Q = reaction quotient
I =current in amperes
q = charge in coulombs

R, Gas constant = $\frac{\text{8.31 Joules}}{\text{Mole Kelvin}}$
= $0.0821 \frac{\text{liter atm}}{\text{mole Kelvin}}$
= $8.31 \frac{\text{volts coulombs}}{\text{mole Kelvin}}$

Boltzmann's constant,
$k = 1.38 \times 10^{-23} \frac{\text{Joule}}{\text{K}}$

$K_{f\ water}$ = 1.86 Kelvin /molal
$K_{b\ water}$ = 0.512 Kelvin /molal

STP = 0.00 ^oC, 1.00 atm (101.3 kPa)

1 faraday ℑ = 96,500 coulombs/ mole of electrons

ATOMIC STRUCTURE

$\Delta E = h\nu$

$c = \nu\lambda$

$\lambda = \frac{h}{mv}$

$p = mv$

$E_n = \frac{-2.178 \times 10^{-18}}{n^2}$ joule

E = energy
ν = frequency
λ = wavelength
p = momentum
v = velocity
n = principal quantum number
c = speed of light 3.00×10^{8} m/s
h = Planck's constant = 6.63×10^{-34} Joule s
k = Boltzmann constant = 1.38×10^{-23} joule/K
Avogadro's number = 6.02×10^{23} molecules/mole
e = electron charge = -1.602×10^{-19} coulomb
1 electron volt/atom = 96.5×10^{23} kj/mole

OXIDATION-REDUCTION ELECTROCHEMISTRY

$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$

where a B + b B ⇔ c C + d D

I = q/t   I = amperes, q = charge in coulombs, t = time in seconds.

$E_{cell} = E^o_{cell} - \frac{RT}{n\mathfrak{I}}\ln Q = E^o_{cell} - \frac{0.0592}{n}\log Q$ @ 25°C

$\log K = \frac{nE^o}{0.0592}$

1 Faraday ℑ = 96,500 coulombs/mole

EQUILIBRIUM

$K_w = 1 \times 10^{-14}$ at 25°C

$pH = -\log[H^+]$; $pOH = -\log[OH^-]$

pH + pOH = 14

$pH = pK_a + \log\frac{[A^{-1}]}{[HA]}$

$pOH = pK_b + \log\frac{[HB^+]}{[B]}$

$pK_a = -\log K_a$, $pK_b = -\log K_b$

$K_p = K_c(RT)^{\Delta n}$

Δn = moles product gas – moles reactant gas

EQUILIBIRUM TERMS

K_a = weak acid
K_b = weak base
K_w = water
K_p = gas pressure
K_c = molar concentration

KINETICS EQUATIONS

$A_o - A = kt$ A_0 is initial concentration, amount.

$$\ln\frac{A_o}{A} = kt$$

$$\frac{1}{A} - \frac{1}{A_o} = kt$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

THERMOCHEMISTRY

$\Delta S^o = \sum\Delta S^o$ products – $\sum\Delta S^o$ reactants

$\Delta H^o = \sum\Delta H^o$ products – $\sum\Delta H^o$ reactants

$\Delta G^o = \sum\Delta G^o$ products – $\sum\Delta G^o$ reactants

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

$\Delta G^o = -RT\ln K = -2.303\,RT\log K$

$\Delta G^o = -n\mathfrak{I}E^o$

$\Delta G = \Delta G^o + RT\ln Q = \Delta G^o + 2.303\,RT\log Q$

$q = mC\Delta T$

$C_p = \frac{\Delta H}{\Delta T}$

$q = mH_f$

$q = mH_v$.

S^o = standard entropy
H^o = standard enthalpy
G^o = standard free energy
E^o = standard reduction potential
T = temperature
q = heat
c = specific heat capacity

C_p = molar heat capacity at constant pressure
1 faraday ℑ = 96,500 coulombs/mole

$C_{water} = \frac{4.18 \text{ joule}}{\text{g K}}$

$H_f = \frac{330 \text{ joules}}{\text{gram}}$ for water

$H_v = \frac{2260 \text{ joules}}{\text{gram}}$ for water

METAL ACTIVITY SERIES

Metal	*Metal Ion*
Lithium	Li^{+1}
Potassium	K^{+1}
Calcium	Ca^{+2}
Sodium	Na^{+1}
Magnesium	Mg^{+2}
Aluminum	Al^{+3}
Manganese	Mn^{+2}
Zinc	Zn^{+2}
Chromium	Cr^{+2}, Cr^{+3}
Iron	Fe^{+2}, Fe^{+3}
Lead	Pb^{+2}, Pb^{+4}
Copper	Cu^{+1}, Cu^{+2}
Mercury	Hg^{+2}
Silver	Ag^{+1}
Platinum	Pt^{+2}
Gold	Au^{+1}, Au^{+3}

Chemistry I Answer Key **PINK TEST**

Date: Thursday January 9, 2014 Corrections in ( )

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

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

January Test has the following topics: scientific method, measurement, dimensional analysis, properties, density, graphing, mixtures, compounds, formulas, mole, mass percent, writing and balancing chemical reactions, using the metal and non-metal activity series for writing chemical reactions, types of reactions, stoichiometry, atomic structure and history, but not electronic configuration.

February Test: Quantum Theory, Electronic structure, orbital notation, dot notation, periodic behavior, specific heat, heat of phase changes, molar heat of fusion, molar heat of vaporization , 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, mole fraction as applied to gases, plus January and February topics.

April Test: solutions, solubility rules, reaction rates, chemical equilibrium, entropy, reaction spontaneity, Keq, acids, bases, salts, net ionic equations, thermo chemistry, ΔH, Hess's law, plus January, February, and March topics.

Dates for 2014 Season

Thursday January 9, 2014 Thursday February 13, 2014

Thursday March 13, 2014 Thursday April 10, 2014

New Jersey Science League

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What is to be mailed back to our office?

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

New Jersey Science League - Chemistry I Exam
February 2014

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. When balancing chemical equations, reduce all coefficients to the lowest whole numbers.

1. Given the following types of electromagnetic radiation: gamma, infrared, X-rays, microwaves, visible light, ultraviolet, radio. Arrange them in the order of **increasing energy**:
   A. gamma, X-rays, ultraviolet, visible light, infrared, microwaves, radio
   B. visible light, X-rays, gamma, radio, microwaves, ultraviolet, infrared
   C. infrared, gamma, X-rays, microwaves, visible light, ultraviolet, radio
   D. radio, microwaves, infrared, visible light, ultraviolet, X-rays, gamma

2. Emission spectra (bright line spectra) may be **directly** attributed to an electron
   A. spiraling into a nucleus.
   B. changing its atomic energy level.
   C. reversing its direction of spin.
   D. escaping from the atom.
   E. absorbing energy from an outside source.

3. The energy of the hydrogen atom in the ground state (n = 1) is -21.79×10^{-19} J. A particle strikes a hydrogen atom and excites the electron to its 5th energy level (n = 5) corresponding to an energy of -0.87×10^{-19} J. If the electron returns to the ground state in one step, what is the energy of the photon emitted?
   A. 4.18×10^{-19} J B. 5.48×10^{-19} J C. 20.92×10^{-19} J D. 22.66×10^{-19} J

4. An argon atom is isoelectronic with
   A. Cl B. Ca C. Ti^{4+} D. Mn^{5+} E. K

5. Which electron configuration is **impossible**?
   A. $1s^2 2s^2 2p^6 3s^2$ B. $1s^2 2s^2 2p^6 2d^2$ C. $1s^2 2s^2 2p^6 3s^2 3p^6$ D. $1s^2 2s^2 2p^5 3s^1$

6. A metal, **M**, forms an oxide with a formula of $\mathbf{M}_2O_3$. The ground state valence shell electron configuration of the **M** atom may be
   A. $ns^2\ np^1$ B. np^3 C. $4s^1\ 3p^6$ D. $4f^7$ E. $5s^2\ 5p^3$

7. Which element in Period 5, Group 3A(13), has the outer electron configuration of
   A. $5s^2 5p^1$ B. $3s^2 3p^5$ C. $3s^2 3p^3$ D. $5s^2 5p^3$

8. Which Lewis electron-dot diagram correctly represents an **ion** of an element found in period 3, and group 15?

9. Which atom description represents a particle (ion) with an electrical charge of 1+?

A.

Nucleus	*n* = 1	*n* = 2	*n* = 3	*n* = 4
3 *p*, 4 *n*	2 e^-			

B.

Nucleus	*n* = 1	*n* = 2	*n* = 3	*n* = 4
11 *p*, 12 *n*	2 e^-	8 e^-	1 e^-	

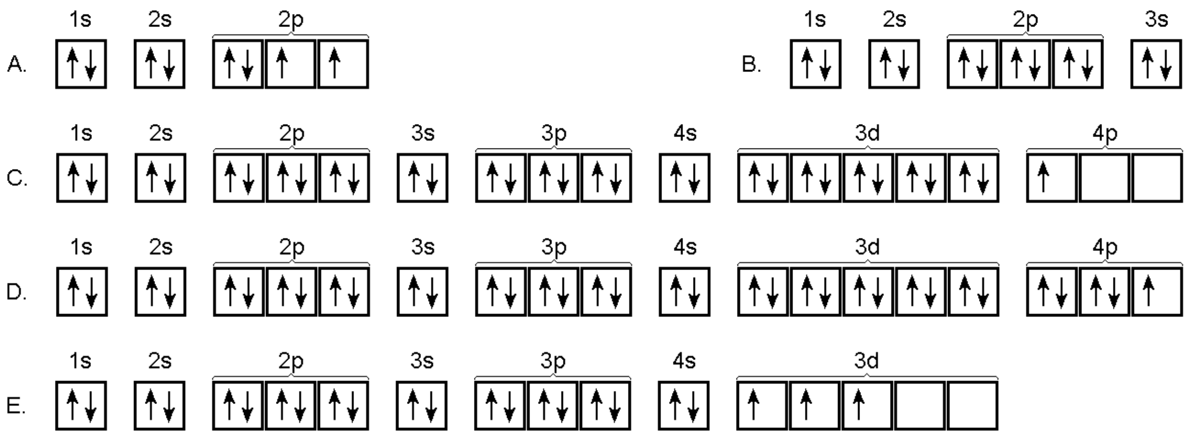
C.

Nucleus	*n* = 1	*n* = 2	*n* = 3	*n* = 4
11 *p*, 12 *n*	2 e^-	8 e^-	18 e^-	1 e^-

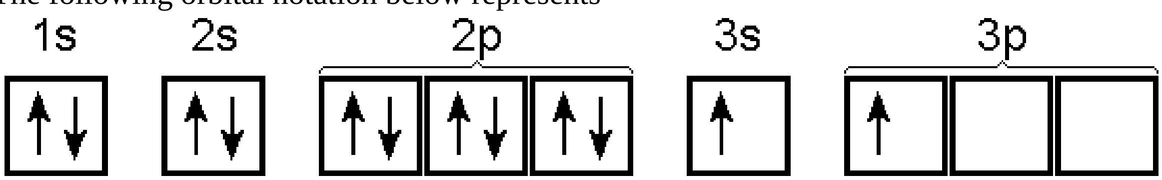
D.

Nucleus	*n* = 1	*n* = 2	*n* = 3	*n* = 4
8 *p*, 10 *n*	2 e^-	6 e^-		

10. Which orbital notation correctly represents an atom of a **transition element** in the ground state?



11. The following orbital notation below represents



A. a magnesium atom in the ground state
B. a magnesium atom in an excited state
C. a magnesium ion in an excited state
D. a magnesium ion in the ground state

12. More heat is derived from cooling one gram of steam at 100°C to 50°C than from cooling one gram of liquid water at 100°C to 50°C because

A. water is a poor thermal conductor.
B. the steam is hotter than the water.
C. the steam occupies a greater volume than water.
D. the heat of condensation is evolved.
E. the density of water is greater than that of steam.

13. Use this section of a periodic table shown on the right. If atoms of R have one electron in the "*d*" sublevel, what is the formula for a nitride of element **A**?
<u>Note</u>: The letters used are not the actual symbols for the elements they represent.

A	E
Q	R

A. $\mathbf{A}_3N$ B. $\mathbf{A}_3N_2$ C. **A**N D. $\mathbf{A}N_2$ E. $\mathbf{A}_2N_3$

14. Which element in this periodic table loses electrons most readily? Note: The letters used are **not** the actual symbols for the elements they represent.

	Main Groups							
Group Numbers	1A	2A	3A	4A	5A	6A	7A	8A
First Period	**D**							**E**
Second Period	**G**		**J**		**K**	**L**	**M**	
Third Period	**Q**	**R**		**T**	**X**		**Z**	

A. **G** B. **E** C. **M** D. **Q** E. **Z**

15. Among the alkali metals, cesium reacts more rapidly with water than sodium. To what may this be **directly** ascribed?

A. Cesium has a higher nuclear charge.
B. Cesium has a higher atomic mass.
C. Cesium has more electrons.
D. Cesium has more neutrons.
E. The valence electron in cesium is at a greater average distance from the nucleus.

16. An English scientist, John Newlands in 1864 contributed to the formation of the modern Periodic Table by

A. observing that properties of known elements arranged in order of the increasing atomic masses repeated every eighth element.
B. observing that groups of three elements with similar properties existed which, when arranged in order of increasing atomic masses, the average of the first and third of those weights equaled the mass of the middle element.
C. arranging the elements in rows according to similarity of properties.
D. performing experiments that led him to suggest that increasing atomic number be used instead of atomic mass to arrange elements in rows of the periodic table.

17. Which equation describes the melting of a pure solid?

A. $X(s) + \text{energy} \rightleftarrows X(g)$
B. $X(l) + \text{energy} \rightleftarrows X(s)$
C. $X(s) + \text{energy} \rightleftarrows X(l)$
D. $X(l) + \text{energy} \rightleftarrows X(g)$
E. $X(g) \rightleftarrows X(s) + \text{energy}$

18. Determine the empirical formula for hydrated lithium nitrate from the following laboratory data:

mass of hydrated lithium nitrate	17.00 g
mass of anhydrous lithium nitrate	9.53 g

A. $LiNO_3 \bullet H_2O$
B. $LiNO_3 \bullet 25H_2O$
C. $LiNO_3 \bullet 7H_2O$
D. $LiNO_3 \bullet 4H_2O$
E. $LiNO_3 \bullet 3H_2O$

19. Rutherford's model of the atom differed from Bohr's model because

A. Rutherford's model showed protons and neutrons in the nucleus, while Bohr's model did not.
B. Rutherford's model showed the most probable location of electrons in the form of diffuse clouds of negative charge, while Bohr's model did not.
C. Rutherford's model showed the atom as a solid sphere, while Bohr's model included protons, neutrons and electrons.
D. Rutherford's model did not place electrons in energy levels, while Bohr's model did.
E. Rutherford's model showed the atom to consist of low density positively charged matter with tiny negatively charged particles embedded in it, while Bohr's model showed the nucleus consisting of protons and neutrons, and electrons orbiting the nucleus in circular orbits.

20. For which compound are the empirical and molecular formulas the same?
A. $C_6H_4(COOH)_2$ B. HOOCCOOH C. CH_3COOH D. C_6H_5COOH

21. When alpha particles were shot at a gold foil target, most of the particles were undeflected. This indicated to Rutherford that
A. the gold foil was continuous matter.
B. the mass of the gold atoms was spread out thinly.
C. the atoms of gold were mostly empty space.
D. the alpha particles had great penetrating power.
E. the alpha particles had charges opposite to those on the nuclei of gold atoms.

22. Molar mass of an unknown solid compound was determined to be 352 g/mol. If 62.5 J is required to melt 100. g of this substance at its melting point at constant temperature, what is its **molar** heat of fusion.
A. 35,200 J/mol B. 284 J/mol C. 130. J/mol D. 625 J/mol E. 220. J/mol

23. The molar heat of vaporization of carbon disulfide, CS_2 is 28.4 kJ/mol at its normal boiling point of 46°C. How much heat is required to vaporize 1.0 g of CS_2 at 46°C?
A. 2.2 kJ B. 28 kJ C. 0.37 kJ D. 0.13 kJ E. 1.0 kJ

24. A bright-line spectrum contains a line equivalent to a wavelength of 518 nanometers. Determine the energy of its photons. [1 m = 10^9 nm c = 3.0×10^8 m/s h = 6.626×10^{-34} J/s]
A. 5.18×10^{-7} J B. 6.63×10^{-34} J C. 3.00×10^8 J D. 3.83×10^{-19} J E. 1.03×10^{-19} J

25. Given the following information:
specific heat of $H_2O(l)$ = 4.2 $J \cdot g^{-1} \cdot {}^oC^{-1}$ heat of fusion of $H_2O(s)$ = 335 $J \cdot g^{-1}$
specific heat of $H_2O(s)$ = 1.1 $J \cdot g^{-1} \cdot {}^oC^{-1}$
If a 250 g piece of ice at 0°C is placed in 250 g of hot water at 100°C, the final temperature of the mixture formed is **closest to**
A. 0°C B. 10.°C C. 20.°C D. 43°C E. 85°C

Periodic Table and Chemistry Formulas

Periodic Table of the Elements

[amu to 5 significant digits]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116	117	118

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	Lanthanide Series
89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	Actinide Series

CHEMISTRY FORMULAS

GASES, LIQUIDS, SOLUTIONS

$PV = nRT$

$\frac{(P + n^2a)}{V^2}(V - nb) = nRT$

$P_A = P_{total} \bullet X_A$

$P_{total} = P_A + P_B + P_C + $

$n = \frac{m}{M}$

Kelvin = °C + 273

$P_1V_1 = P_2V_2$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$d = \frac{m}{V}$

$u_{rms} = \sqrt{\frac{3kt}{m}} = \sqrt{\frac{3RT}{M}}$

$KE_{per\ molecule} = \frac{mv^2}{2}$

$KE_{per\ mole} = \frac{3RT}{2}$

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

M, molarity = $\frac{\text{moles solute}}{\text{liter of solution}}$

molality = $\frac{\text{moles of solute}}{\text{kg of solvent}}$

$\Delta T_f = iK_f \bullet \text{molality}$

$\Delta T_b = iK_b \bullet \text{molality}$

$\pi = \frac{nRTi}{V}$

P = pressure
V = volume
T = Temperature
n = number of moles
d = density
m = mass
v = velocity
where $X_A = \frac{\text{moles A}}{\text{total moles}}$
u_{rms} = root-mean-square-root
KE = Kinetic energy
r = rate of effusion
M = Molar mass
π = osmotic pressure
i = van't Hoff factor
K_f = molal freezing point constant
K_b = molal boiling point constant
Q = reaction quotient
I = current in amperes
q = charge in coulombs
t = time
E° = standard reduction potential
Keq = equilibrium constant

R, Gas constant = $\frac{8.31 \text{ Joules}}{\text{Mole Kelvin}}$
$= 0.0821 \frac{\text{liter atm}}{\text{mole Kelvin}}$
$= 8.31 \frac{\text{volts coulombs}}{\text{mole Kelvin}}$

Boltzmann's constant, $k = 1.38 \times 10^{-23} \frac{\text{Joule}}{\text{K}}$

$K_{f\ water}$ = 1.86 Kelvin /molal
$K_{b\ water}$ = 0.512 Kelvin /molal

STP = 0.00 °C, 1.00 atm (101.3 kPa)

1 faraday ℑ = 96,500 coulombs/ mole of electrons

ATOMIC STRUCTURE

$\Delta E = h\nu$

$c = \nu\lambda$

$\lambda = \frac{h}{mv}$

$p = mv$

$E_n = \frac{-2.178 \times 10^{-18}}{n^2}$ joule

E = energy
ν = frequency
λ = wavelength
p = momentum
v = velocity
n = principal quantum number
c = speed of light 3.00×10^8 m/s
h = Planck's constant = 6.63×10^{-34} Joule s
k = Boltzmann constant = 1.38×10^{-23} joule/K
Avogadro's number = 6.02×10^{23} molecules/mole
e = electron charge = -1.602×10^{-19} coulomb
1 electron volt/atom = 96.5×10^{23} kj/mole

OXIDATION-REDUCTION ELECTROCHEMISTRY

$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$

where aB + bB ⇔ cC + dD

$I = q/t$ I = amperes, q = charge in coulombs, t = time in seconds.

$E_{cell} = E^o_{cell} - \frac{RT}{n\Im}\ln Q = E^o_{cell} - \frac{0.0592}{n}\log Q$ @ 25°C

$\log K = \frac{nE^o}{0.0592}$

1 Faraday ℑ = 96,500 coulombs/mole

EQUILIBRIUM

$K_w = 1 \times 10^{-14}$ at 25°C

$pH = -\log[H^+]$; $pOH = -\log[OH^-]$

$pH + pOH = 14$

$pH = pK_a + \log\frac{[A^{-1}]}{[HA]}$

$pOH = pK_b + \log\frac{[HB^+]}{[B]}$

$pK_a = -\log K_a$, $pK_b = -\log K_b$

$K_p = K_c(RT)^{\Delta n}$

Δn = moles product gas – moles reactant gas

EQUILIBIRUM TERMS

K_a = weak acid
K_b = weak base
K_w = water
K_p = gas pressure
K_c = molar concentration

KINETICS EQUATIONS

$A_o - A = kt$ A_0 is initial concentration, amount.

$$\ln\frac{A_o}{A} = kt$$

$$\frac{1}{A} - \frac{1}{A_o} = kt$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

THERMOCHEMISTRY

$\Delta S^o = \sum\Delta S^o$ products $- \sum\Delta S^o$ reactants

$\Delta H^o = \sum\Delta H^o$ products $- \sum\Delta H^o$ reactants

$\Delta G^o = \sum\Delta G^o$ products $- \sum\Delta G^o$ reactants

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

$\Delta G^o = -RT\ln K = -2.303\,RT\log K$

$\Delta G^o = -n\Im E^o$

$\Delta G = \Delta G^o + RT\ln Q = \Delta G^o + 2.303\,RT\log Q$

$q = mC\Delta T$

$C_p = \frac{\Delta H}{\Delta T}$

$q = mH_f$

$q = mH_v$.

S° = standard entropy
H° = standard enthalpy
G° = standard free energy
E° = standard reduction potential
T = temperature
q = heat
c = specific heat capacity

C_p = molar heat capacity at constant pressure

1 faraday ℑ = 96,500 coulombs/mole

$C_{water} = \frac{4.18 \text{ joule}}{g\,K}$

$H_f = \frac{330 \text{ joules}}{\text{gram}}$ for water

$H_v = \frac{2260 \text{ joules}}{\text{gram}}$ for water

METAL ACTIVITY SERIES

Metal	*Metal Ion*
Lithium	Li^{+1}
Potassium	K^{+1}
Calcium	Ca^{+2}
Sodium	Na^{+1}
Magnesium	Mg^{+2}
Aluminum	Al^{+3}
Manganese	Mn^{+2}
Zinc	Zn^{+2}
Chromium	Cr^{+2}, Cr^{+3}
Iron	Fe^{+2}, Fe^{+3}
Lead	Pb^{+2}, Pb^{+4}
Copper	Cu^{+1}, Cu^{+2}
Mercury	Hg^{+2}
Silver	Ag^{+1}
Platinum	Pt^{+2}
Gold	Au^{+1}, Au^{+3}

Chemistry I Answer Key
Date: Thursday February 13, 2014

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

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, stoichiometry, atomic structure and history, but not electronic configuration.
February Test: Quantum Theory, Electronic structure, orbital notation, dot notation, periodic behavior, specific heat, heat of phase changes, molar heat of fusion, molar heat of vaporization , 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, mole fraction as applied to gases, plus January and February topics.
April Test: solutions, solubility rules, reaction rates, chemical equilibrium, entropy, reaction spontaneity, Keq, acids, bases, salts, net ionic equations, thermo chemistry, ΔH, Hess's law, plus January, February, and March topics.

Dates for 2014 Season

Thursday January 9, 2014 Thursday February 13, 2014

Thursday March 13, 2014 Thursday April 10, 2014

All areas and schools must complete the last exam and mail in the results by April 25th, 2014

New Jersey Science League

PO Box 65 Stewartsville, NJ 08886-0065

phone # 908-213-8923 fax # 908-213-9391 email newjsl@ptd.net **Web address:**

www://entnet.com/~personal/njscil/html

PLEASE RETURN THE AREA RECORD AND ALL TEAM MEMBER SCANTRONS(ALL STUDENTS PLACING 1ST, 2ND, 3RD, AND 4TH).

If you return scantrons of alternates, then label them as ALTERNATES.

Dates for 2015 Season

Thursday January 8, 2015 Thursday February 12, 2015

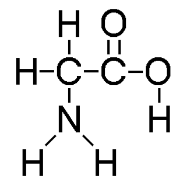
Thursday March 12, 2015 Thursday April 9, 2015

New Jersey Science League - Chemistry I Exam
March 2014

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. When balancing chemical equations, reduce all coefficients to the lowest whole numbers.

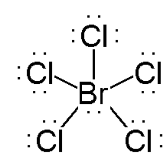
1. Which choice has ***sp***^{1} hybridization on its central atom?
   A. H_2O B. NH_3 C. CO_2 D. HCHO E. none of them

2. The diagram at the right is a structural representation of glycine, the smallest amino acid molecule, one of the building blocks of proteins. How many **sigma** and **pi** bonds are present in this molecule?
   A. 7 sigma bonds and 3 pi bonds B. 6 sigma bonds and 2 pi bonds
   C. 10 sigma bonds and 0 pi bonds D. 1 sigma bonds and 9 pi bonds
   E. 9 sigma bonds and 1 pi bond

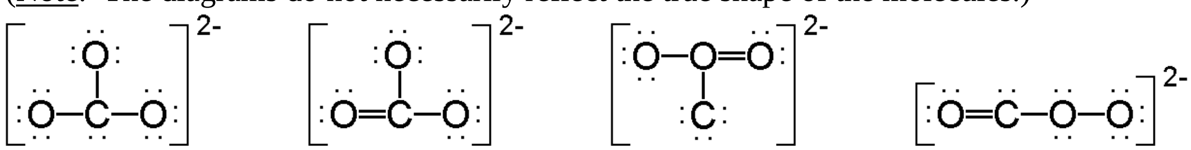


3. Which of the following molecules contains two double covalent bonds?
   A. $CH_2CHCHCH_2$ B. CHC_2CH_3 C. CH_3COOH D. $C_3H_5(OH)_3$ E. $NH_2CHCHNH_2$

4. The diagram on the right represents the Lewis structure of $BrCl_5$. Its molecular shape is
   A. octahedral B. trigonal pyramidal C. square pyramidal
   D. trigonal planar E. tetrahedral

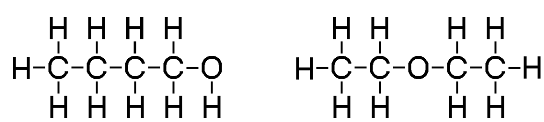


5. Which Lewis diagram below is the most plausible structure of the carbonate ion [CO_3^{2-}]?
   (Note: The diagrams do not necessarily reflect the true shape of the molecules.)



A. B. C. D.

6. Which statement best describes the two molecules represented by the diagrams below?
   A. They are both isomers of one another.
   B. They both represent the same compound.
   C. They have different empirical formulas.
   D. They are called isotopes of the same substance.
   E. They are called allotropes of the same substance.

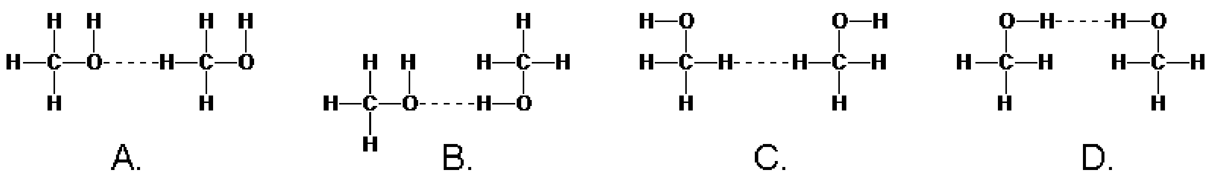


7. Which substance has an abnormally high boiling point due to the existence of hydrogen bonding between its molecules?
   A. MgF_2 B. HCl C. H_2S D. CH_4 E. H_2O

8. The fact that BF_3 is a trigonal planar molecule, while PBr_3 is trigonal pyramidal, can **best** be explained by the following statement:
A. Phosphorus is more electronegative than boron.
B. The phosphorus atom in PBr_3 is smaller than the boron atom in BF_3.
C. The boron atom in BF_3 is sp^3 hybridized, while the phosphorus atom in PBr_3 is sp^2 hybridized.
D. The phosphorus atom in PBr_3 has a lone pair of electrons whereas the boron atom in BF_3 does not.

9. At room temperature, oxygen behaves more like an ideal gas than water vapor. The best **experimental evidence** for this is
A. Molecules of water vapor attract each other more strongly than molecules of oxygen do.
B. When subjected to pressure, water vapor is more easily liquefied than oxygen gas.
C. Water vapor is a compound, while oxygen is an element.
D. Water vapor molecules are triatomic, while molecules of oxygen are diatomic.
E. Water vapor molecules are polar, while molecules of oxygen are nonpolar.

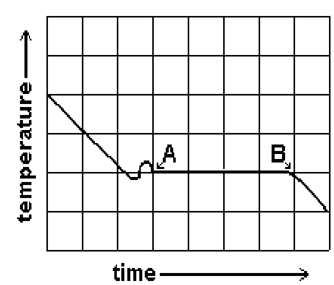
10. Which diagram best represents hydrogen bonding between molecules of methanol (CH_3OH) in the liquid phase?



11. Given four identical 1-Liter glass flasks filled with hydrogen, xenon, chlorine, and oxygen respectively at STP. Which choice correctly ranks the gases in order of **increasing** average velocity of their molecules?
A. xenon, chlorine, oxygen, hydrogen
B. hydrogen, oxygen, chlorine, xenon
C. oxygen, xenon, hydrogen, chlorine
D. chlorine, xenon, oxygen, hydrogen
E. hydrogen, chlorine, oxygen, xenon

12. Which group in the periodic table of the elements contains most powerful reducing agents?
A. the halogen family
B. the noble gases
C. the alkali family
D. the alkaline earth family
E. the oxygen family

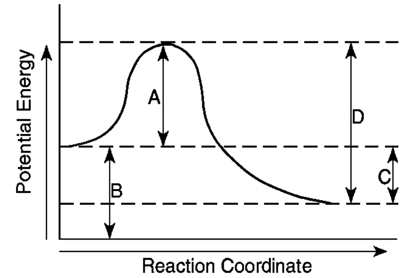
13. The graph on the right represents the cooling curve of one gram of a pure liquid. The length of the line AB depends on
A. the specific heat of the pure solid
B. the specific heat of the pure liquid
C. the boiling point of the pure substance
D. the melting point of the pure substance
E. the heat of fusion of the pure substance



14. Given three rigid 1.00-Liter containers at 25^{o} C filled with 1.00 mole of helium gas, 2.00 moles of neon gas, and 3.00 moles of argon gas respectively. When all three gases are pumped into a fourth 1.00-Liter container, what is the volume occupied by the **neon** gas in the final mixture?
A. 1.00 L
B. 2.00 L
C. 3.00 L
D. 0.167 L
E. 0.333 L

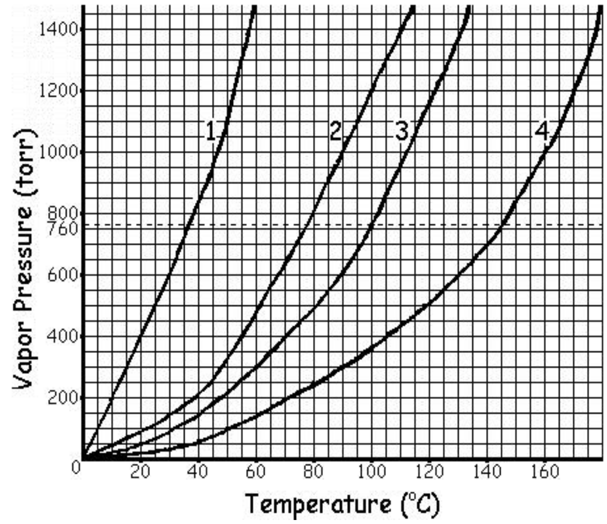
15. Which line in the diagram on the right, represents the activation energy for the reverse reaction?

A. A B. B C. C D. D

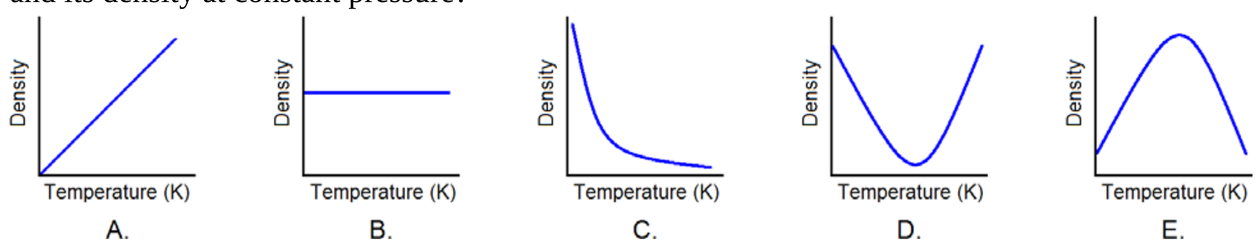


16. Given the Vapor Pressure graphs for substances 1, 2, 3, and 4. What is the phase of substance "2" at 45°C and 600 torr?

A. liquid B. gas C. solid D. plasma E. vapor



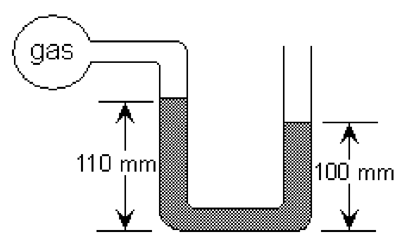
17. Which graph represents the relationship between Kelvin temperature of a sample of an ideal gas and its density at constant pressure?



18. The diagram on the right represents a mercury manometer with a gas bulb attached. The height of the mercury column in the right arm open to atmospheric pressure of 760 mm Hg is 100 mm, while the height of the mercury in the left arm is 110 mm. What is the pressure exerted by the gas in the bulb?

A. 10 mm Hg B. 750 mm Hg

C. 770 mm Hg D. 220 mm Hg



19. A gas cylinder with a volume of 350. cm^3 contains 4.50 g of carbon dioxide gas at 25.0 °C. The label on the cylinder warns that exposure to temperatures above 100.°C may cause the cylinder to burst. What would the pressure of carbon dioxide be at this temperature?

A. 28.66 atm B. 7.15 atm C. 3.50 atm D. 2.98 atm E. 8.95 atm

20. When the absolute temperature of a fixed quantity of an ideal gas is doubled, and the pressure is halved, what is the net effect on the volume of the gas?
A. The volume remains constant B. The volume is doubled C. The volume is quadrupled
D. The volume is tripled. E. The volume is halved.

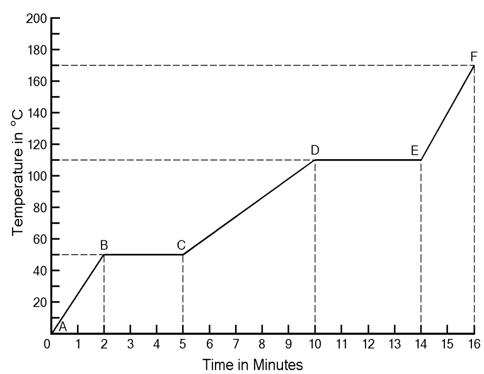
21. Two rigid containers of equal size are filled with nitrogen gas and oxygen gas respectively at the same temperature and pressure. If the mass of nitrogen gas in the first container is 12.0 g, what is the mass of the oxygen gas in the second container?
A. 16.0 g B. 28.0 g C. 32.0 g D. 13.7 g E. 12.0 g

22. Given a mixture of gases: 4.00 g of helium, 34.1 g of ammonia, and 132.0 g of carbon dioxide, in a 20.0 L steel container. Which answer is closest to the total pressure inside the container at 65.0^{o}C?
A. 8.50 atm B. 1.39 atm C. 2.78 atm D. 4.16 atm E. 0.999 atm

23. At 400.^{o}C and 0.878 atm, 4.55 Liters of $NO_2(g)$ are converted completely to $N_2O_4(g)$ at 0.00^{o}C and 0.945 atm. The balanced equation for this reaction is $2\ NO_2(g) \rightarrow N_2O_4(g)$. What volume does the $N_2O_4(g)$ gas sample occupy?
A. 0.000 L B. 3.42 L C. 2.44 L D. 0.858 L E. 1.71 L

24. A piece of magnesium ribbon reacts with an excess of dilute hydrochloric acid producing 378 mL of hydrogen gas collected over water at 300. K. If the vapor pressure of water at that temperature is 26.7 mm Hg, and the barometric pressure is 730 mm Hg, what is the mass of magnesium used in this reaction?
A. 2.24 g B. 0.345 g C. 0.703 g D. 0.925 g E. 3.00 g

25. The graph on the right represents 10 grams of a solid substance being heated at the rate of 100 calories per minute. Which property of this substance involves the greatest quantity of heat?
A. specific heat of the solid B. specific heat of the liquid
C. specific heat of the gas D. heat of fusion
E. heat of vaporization



Periodic Table and Chemistry Formulas

Periodic Table of the Elements

[amu to 5 significant digits]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116	117	118

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	Lanthanide Series
89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	Actinide Series

CHEMISTRY FORMULAS

GASES, LIQUIDS, SOLUTIONS

$PV = nRT$

$\frac{(P + n^2a)\ (V - nb)}{V^2} = nRT$

$P_A = P_{total} \bullet X_A$

$P_{total} = P_A + P_B + P_C +$

$n = \frac{m}{M}$

Kelvin = °C + 273

$P_1V_1 = P_2V_2$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$d = \frac{m}{V}$

$u_{rms} = \sqrt{\frac{3kt}{m}} = \sqrt{\frac{3RT}{M}}$

$KE_{per\ molecule} = \frac{mv^2}{2}$

$KE_{per\ mole} = \frac{3RT}{2}$

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

M, molarity = $\frac{\text{moles solute}}{\text{liter of solution}}$

molality = $\frac{\text{moles of solute}}{\text{kg of solvent}}$

$\Delta T_f = iK_f \bullet$ molality

$\Delta T_b = iK_b \bullet$ molality

$\pi = \frac{nRTi}{V}$

P = pressure
V = volume
T = Temperature
n = number of moles
d = density
m = mass
v = velocity
where $X_A = \frac{\text{moles A}}{\text{total moles}}$

u_{rms} = root-mean-square-root
KE = Kinetic energy
r = rate of effusion
M = Molar mass
π = osmotic pressure
i = van't Hoff factor
K_f = molal freezing point constant
K_b = molal boiling point constant
Q = reaction quotient
I =current in amperes
q = charge in coulombs
t = time
E° = standard reduction potential
Keq = equilibrium constant

R, Gas constant = $\frac{8.31 \text{ Joules}}{\text{Mole Kelvin}}$
$= 0.0821 \frac{\text{liter atm}}{\text{mole Kelvin}}$
$= 8.31 \frac{\text{volts coulombs}}{\text{mole Kelvin}}$

Boltzmann's constant,
$k = 1.38 \times 10^{-23} \frac{\text{Joule}}{\text{K}}$

$K_{f\ water}$ = 1.86 Kelvin /molal
$K_{b\ water}$ = 0.512 Kelvin /molal

STP = 0.00 °C, 1.00 atm (101.3 kPa)

1 faraday ℑ = 96,500 coulombs/ mole of electrons

ATOMIC STRUCTURE

$\Delta E = h\nu$

$c = \nu\lambda$

$\lambda = \frac{h}{mv}$

$p = mv$

$E_n = \frac{-2.178 \times 10^{-18}}{n^2}$ joule

E = energy
ν = frequency
λ = wavelength
p = momentum
v = velocity
n = principal quantum number
c = speed of light 3.00×10^{8} m/s
h = Planck's constant = 6.63×10^{-34} Joule s
k = Boltzmann constant = 1.38×10^{-23} joule/K
Avogadro's number = 6.02×10^{23} molecules/mole
e = electron charge = -1.602×10^{-19} coulomb
1 electron volt/atom = 96.5×10^{23} kj/mole

OXIDATION-REDUCTION ELECTROCHEMISTRY

$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$

where $aB + bB \Leftrightarrow cC + dD$

$I = q/t$ I = amperes, q = charge in coulombs, t = time in seconds.

$E_{cell} = E^o_{cell} - \frac{RT}{n\Im}\ln Q = E^o_{cell} - \frac{0.0592}{n}\log Q$ @ 25°C

$\log K = \frac{nE^o}{0.0592}$

1 Faraday ℑ = 96,500 coulombs/mole

EQUILIBRIUM

$K_w = 1 \times 10^{-14}$ at 25°C

$pH = -\log[H^+]$; $pOH = -\log[OH^-]$

$pH + pOH = 14$

$pH = pK_a + \log\frac{[A^{-1}]}{[HA]}$

$pOH = pK_b + \log\frac{[HB^+]}{[B]}$

$pK_a = -\log K_a$, $pK_b = -\log K_b$

$K_p = K_c(RT)^{\Delta n}$

Δn = moles product gas – moles reactant gas

EQUILIBIRUM TERMS

K_a = weak acid
K_b = weak base
K_w = water
K_p = gas pressure
K_c = molar concentration

KINETICS EQUATIONS

$A_o - A = kt$ A_0 is initial concentration, amount.

$$\ln\frac{A_o}{A} = kt$$

$$\frac{1}{A} - \frac{1}{A_o} = kt$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

THERMOCHEMISTRY

$\Delta S^o = \Sigma\Delta S^o$ products – $\Sigma\Delta S^o$ reactants

$\Delta H^o = \Sigma\Delta H^o$ products – $\Sigma\Delta H^o$ reactants

$\Delta G^o = \Sigma\Delta G^o$ products – $\Sigma\Delta G^o$ reactants

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

$\Delta G^o = -RT\ln K = -2.303\,RT\log K$

$\Delta G^o = -n\Im E^o$

$\Delta G = \Delta G^o + RT\ln Q = \Delta G^o + 2.303\,RT\log Q$

$q = mC\Delta T$

$C_p = \frac{\Delta H}{\Delta T}$

$q = mH_f$

$q = mH_v$.

S^o = standard entropy
H^o = standard enthalpy
G^o = standard free energy
E^o = standard reduction potential
T = temperature
q = heat
c = specific heat capacity

C_p = molar heat capacity at constant pressure

1 faraday ℑ = 96,500 coulombs/mole

$C_{water} = \frac{4.18 \text{ joule}}{g\,K}$

$H_f = \frac{330 \text{ joules}}{\text{gram}}$ for water

$H_v = \frac{2260 \text{ joules}}{\text{gram}}$ for water

METAL ACTIVITY SERIES

Metal	*Metal Ion*
Lithium	Li^{+1}
Potassium	K^{+1}
Calcium	Ca^{+2}
Sodium	Na^{+1}
Magnesium	Mg^{+2}
Aluminum	Al^{+3}
Manganese	Mn^{+2}
Zinc	Zn^{+2}
Chromium	Cr^{+2}, Cr^{+3}
Iron	Fe^{+2}, Fe^{+3}
Lead	Pb^{+2}, Pb^{+4}
Copper	Cu^{+1}, Cu^{+2}
Mercury	Hg^{+2}
Silver	Ag^{+1}
Platinum	Pt^{+2}
Gold	Au^{+1}, Au^{+3}

Chemistry I Answer Key **<u>PINK TEST</u>**
Date: Thursday March 13, 2014

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

<u>CHEMISTRY 1 (No AP or second year students in this category.)</u>

<u>January Test</u> has the following topics: scientific method, measurement, dimensional analysis, properties, density, graphing, mixtures, compounds, formulas, mole, mass percent, writing and balancing chemical reactions, using the metal and non-metal activity series for writing chemical reactions, types of reactions, stoichiometry, atomic structure and history, but not electronic configuration.

<u>February Test</u>: Quantum Theory, Electronic structure, orbital notation, dot notation, periodic behavior, specific heat, heat of phase changes, molar heat of fusion, molar heat of vaporization , plus January topics.

<u>March Test</u>: Chemical bonding, molecular structure, simple isomers, intermolecular attractions, redox but not balancing redox equations, kinetic theory, solids, liquids, gases, gas laws, gas stoichiometry, mole fraction as applied to gases, plus January and February topics.

<u>April Test</u>: solutions, solubility rules, reaction rates, chemical equilibrium, entropy, reaction spontaneity, Keq, acids, bases, salts, net ionic equations, thermo chemistry, ΔH, Hess's law, plus January, February, and March topics.

Testing Dates for 2014

Thursday March 13, 2014 Thursday April 10, 2014

***The April 2014 exam can be changed based upon the Schools spring break.**

The April exam must be completed by **April 25th**. No area may take the April exam during the first week of April or during the first week of May.

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If you return scantrons of alternates, then label them as <u>ALTERNATES</u>.

Dates for 2015 Season

Thursday January 8, 2015 Thursday February 12, 2015

Thursday March 12, 2015 Thursday April 9, 2015

New Jersey Science League - Chemistry I Exam
April 2014

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 sheet 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. When balancing chemical equations, reduce all coefficients to the lowest whole numbers.

1. A student measures the pH of distilled water in an open container every hour for 24 hours using a pH meter. She notices that, over time, at constant temperature, the pH value of the water decreases slightly. The **best** explanation for this phenomenon may be
   A. The molecules of water ionize.
   B. The atmospheric gases nitrogen and oxygen dissolve in the water.
   C. Distillation of water does not remove dissolved substances from water.
   D. Carbon dioxide from the air dissolves in the water.
   E. Carbon dioxide removes hydroxide ions from distilled water.

2. The solubility of potassium nitrate is 50. g per 100. g of water at 32°C. A solution of the same substance was prepared by dissolving 70. g in 100. g of water at 50°C, and then was cooled slowly to 32°C without any solid separating. The **resulting** solution can be described as
   A. saturated at 32°C. B. supersaturated at 32°C. C. supersaturated at 50°C.
   D. saturated at 50°C. E. unsaturated at 32°C.

3. Which choice contains compounds whose water solutions are **both** excellent conductors of electricity?
   A. CH_3COOH and KBr B. H_2S and HNO_3 C. NaI and Ag_2CO_3 D. NaCl and HCl

4. Which two compounds would react by exchange of ions (double replacement) on mixing equal volumes of their dilute solutions?
   A. $FeCl_2(aq)$ and $CuBr_2(aq)$ B. $NaCl(aq)$ and $ZnNO_3(aq)$
   C. $MgCl_2(aq)$ and $K_2SO_4(aq)$ D. $AlBr_3(aq)$ and $NH_4OH(aq)$
   E. $CuBr_2(aq)$ and $Ca(NO_3)_2(aq)$

5. What is the Equilibrium Law Expression for the reaction: $H_2(g) + Br_2(l) \rightleftarrows 2\,HBr(g)$

   $$\text{A. } K_{eq}=\frac{[HBr]^2}{[H_2][Br_2]} \quad \text{B. } K_{eq}=\frac{[HBr]^2}{[H_2]} \quad \text{C. } K_{eq}=\frac{[H_2][Br_2]}{[HBr]^2} \quad \text{D. } K_{eq}=\frac{[H_2]}{[HBr]^2} \quad \text{E. } K_{eq}=\frac{[H_2]}{[2\,HBr]}$$

6. What is the K_{sp} expression for the dissolving of $Mg_3(PO_4)_2$ in water?

   $$\text{A. } K_{sp}=[Mg_3(PO_4)_2] \quad \text{B. } K_{sp}=[Mg^{2+}]^3[PO_4^{3-}]^2 \quad \text{C. } K_{sp}=\frac{1}{[Mg^{2+}]^3[PO_4^{3-}]^2} \quad \text{D. } K_{sp}=\frac{[Mg_3(PO_4)_2]}{[Mg^{2+}]^3[PO_4^{3-}]^2} \quad \text{E. } K_{sp}=\frac{[Mg^{2+}]^3[PO_4^{3-}]^2}{[Mg_3(PO_4)_2]}$$

7. In which rection will an increase in total pressure at constant temperature cause the reaction to form more reactants?

A. $2\ SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$

B. $H_2(g) + Cl_2(g) \rightleftarrows 2\ HCl(g)$

C. $COCl_2(g) \rightleftarrows CO(g) + Cl_2(g)$

D. $2\ NO(g) + O_2(g) \rightleftarrows 2\ NO_2(g)$

E. $N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$

8. Under which conditions does oxygen have the largest entropy per mole?

A. $O_2(s)$ at 100 K and 1 atm

B. $O_2(l)$ at 200 K and 1 atm

C. $O_2(g)$ at 300 K and 1 atm

D. $O_2(g)$ at 300 K and 0.5 atm

9. According to the Brönsted-Lowry definition, which chemical species can function **both** as an acid and as a base?

A. $Br^–$ B. $NO_3^–$ C. NH_4^+ D. $HSO_4^–$ E. H_3O^+

10. Which of these compounds is correctly described or classified?

A. NH_4Cl is a salt of a strong base and a weak acid.
B. SO_3 is the anhydride of sulfuric acid.
C. $CoCl_2•6H_2O$ is the hydride of $CoCl_2$.
D. $HC_2H_3O_2$ is a weak base in water.
E. NaOH is a strong acid.

11. In titrating the weak base, NH_3(aq), with the strong acid, 0.1 M HCl, the equivalence point in pH units will be

A. equal to 7 because neither NH_4^+ nor $Cl^–$ hydrolyze in water solution
B. higher than 7 due to hydrolysis of $Cl^–$
C. higher than 7 due to hydrolysis of NH_4^+
D. lower than 7 due to hydrolysis of $Cl^–$
E. lower than 7 due to hydrolysis of NH_4^+

12. Which is the correct **net ionic equation** for the reaction between copper (II) chloride and sodium hydroxide?

A. $CuCl_2(aq) + 2\ NaOH(aq) \rightarrow Cu(OH)_2(s)$

B. $Cu^{2+}(aq) + 2\ OH^–(aq) \rightarrow Cu(OH)_2(s)$

C. $Cu^{2+}(aq) + 2\ Cl^–(aq) + 2\ Na^+(aq) + 2\ OH^–(aq) \rightarrow Cu(OH)_2(s) + 2\ Cl^–(aq) + 2\ Na^+(aq)$

D. $Na^+(aq) + Cl^–(aq) \rightarrow Na^+Cl^–(aq)$

E. $Na^+(aq) + Cl^–(aq) \rightarrow NaCl(aq)$

13. Given the following data:

$C(s) + ½\ O_2(g) \rightarrow CO(g)$ ΔH = –110 kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = –394 kJ

Calculate ΔH for the reaction: $2\ CO\ (g) + O_2\ (g) \rightarrow 2\ CO_2\ (g)$

A. –568 kJ B. +394 kJ C. –788 kJ D. –220 kJ (E) –110 kJ

14. The formula of potassium arsenate is K_3AsO_4 and that of cadmium bromide is $CdBr_2$. What is the formula of cadmium arsenate?
A. $CdAsO_4$ B. $Cd(AsO_4)_2$ C. $Cd(AsO_4)_3$ D. Cd_2AsO_4 E. $Cd_3(AsO_4)_2$

15. A liter of carbon dioxide gas is compared to a liter of hydrogen gas, both gases at 25°C and 2 atm. Which statement is correct?
A. The CO_2 molecules are on the average moving slower than the H_2 molecules.
B. The average kinetic energy of the CO_2 molecules is greater than that of the H_2 molecules.
C. The CO_2 and H_2 molecules have the same average speed.
D. The CO_2 and H_2 molecules hit the walls of the containers with the same frequency.
E. There are more molecules of H_2 than CO_2 present.

16. Which element in the Periodic table forms an ion that is isoelectronic with the rare gas Kr?
A. N B. Br C. Cl D. Bi E. F

17. 56.0 mL of a 1.60 M solution is diluted to a volume of 228 mL. A 114-mL portion of that solution in turn is diluted by adding 133 mL of water. What is the molar concentration of the final solution?
A. 0.393 M B. 0.337 M C. 0.181 M D. 0.674 M E. 0.169 M

18. What is the pH of an 8.85×10^{-12} M solution of hydroxide ions?
A. 1.130 B. 8.850 C. 2.947 D. 12.885 E. 2.113

19. The ΔH for the combustion of 1 mole of methane, CH_4 is –892 kJ. The heat given off when 1.00 g of methane is burned is closest to
A. 16.04 kJ B. 892 kJ C. 143 kJ D. 556 kJ E. 55.6 kJ

20. How many grams of ethylene glycol $C_2H_4(OH)_2$ must be added to 600. grams of water to make a solution that will freeze at –5.32°C?
A. 124 g B. 600 g C. 106 g D. 2.86 g E. 4.76 g

21. 20.0 g sample of gold is heated to 100.0°C and then added to 50.0 g of water at 25.0°C in an insulated calorimeter and allowed to come to thermal equilibrium. If the specific heat capacity of gold is 0.129 $J \cdot g^{-1} \cdot {}^{o}C^{-1}$, what is the final temperature inside the calorimeter?
A. 25.9°C B. 25.0°C C. 62.5°C D. 30.4°C E. 50.7°C

22. What are the boiling and freezing points of a 0.499 m aqueous solution of any nonvolatile, nonelectrolyte solute? [See reference tables for molal freezing and boiling point constants for water.]
A. Boiling point is 99.74°C, and freezing point is 0.93°C
B. Boiling point is 101.04°C, and freezing point is –3.73°C
C. Boiling point is 100.26°C, and freezing point is –0.93°C
D. Boiling point is 98.96°C, and freezing point is 3.73°C

23. Nitrogen and hydrogen gases are pumped into an empty 5.00-L glass bulb at 500.°C. When equilibrium was established, 3.00 moles of nitrogen, 2.10 moles of hydrogen, and 0.298 moles of ammonia was found to be present. The balanced equation representing this reaction at equilibrium is the following: $N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$. What is the value of K_{eq}?
A. 6.00×10^{-1} B. 4.20×10^{-1} C. 7.99×10^{-2} D. 5.96×10^{-2}

24. The following data were collected for the reaction A + B → C:

Experiment #	Initial [A]	Initial [B]	Initial Rate of Formation of C
1	0.10 M	0.10 M	$0.030\ M\cdot h^{-1}$
2	0.10 M	0.20 M	$0.12\ M\cdot h^{-1}$
3	0.20 M	0.20 M	$0.12\ M\cdot h^{-1}$

Which expression correctly represents the rate law for the above reaction?
A. rate = k [A][B] B. rate = $k\ [A]^2$ C. rate = $k\ [A]^2[B]$
D. rate = $k\ [A]^2[B]^2$ E. rate = $k\ [B]^2$

25. A 473 mL sample of 0.9831 M HCl is mixed with 457 mL sample of KOH (pH = 13.66). What is the final pH of the solution?
A. 0.34 B. 0.21 C. 14.00 D. 13.66 E. 0.56

Chemistry I Answer Key <u>PINK TEST</u>
Date: Thursday April 10, 2014

Record the % correct onto the Area Record

1 D	6 B	11 E	16 B	21A
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