Chemistry II January 2012 Answer Key

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

CHEMISTRY II

JANUARY: matter and measurement, atomic theory(sub-atomic particles, atomic masses), chemical formulas, chemical equations(mole relationships, mass-mass problems), stoichiometry of redox solutions, stoichiometry of molar solutions, electronic structure and periodic table.
FEBRUARY: chemical bonding, electronegativity, Lewis structures, molecular geometry, polarity of molecules, hybridization, liquids, solids, vapor pressure, intermolecular forces, phase changes, gases, plus January topics.
MARCH: thermochemistry(enthalpy, Hess's Law, heats of formation, bond energies, calorimetry), molecular orbitals, non-metals, metals, solutions, colligative properties, descriptive chemistry of the elements, plus Jan and Feb topics.
APRIL: chemical equilibrium, rates of reactions, reaction mechanisms, acids, bases, and salts, Ka, Kb, Ksp, buffers, coordination compounds, redox, voltaic cells, Nernst equations, ΔS, ΔH, ΔG, nuclear chemistry, organic chemistry, descriptive chemistry of the elements, plus Jan, Feb., and Mar topics.

TESTING DAYS FOR THE NEW JERSEY SCIENCE LEAGUE 2011 – 2012

JANUARY TEST: Thursday January 12, 2012
FEBRUARY TEST: Thursday February 9, 2012
MARCH TEST: Thursday March 8, 2012
APRIL TEST: Thursday April 12, 2012

The April 2012 Exam date may change according to the schools in an area spring break.

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New Jersey Science League
Chemistry II Exam January 2012

Answer the following questions on the answer sheet provided. Each correct response is worth 4 points. Use the letters for your answers. Choose the letter that best completes or answers the item. Be certain that erasures are complete. Please **PRINT** your name, school area code, and which test you are taking on the scan-tron.

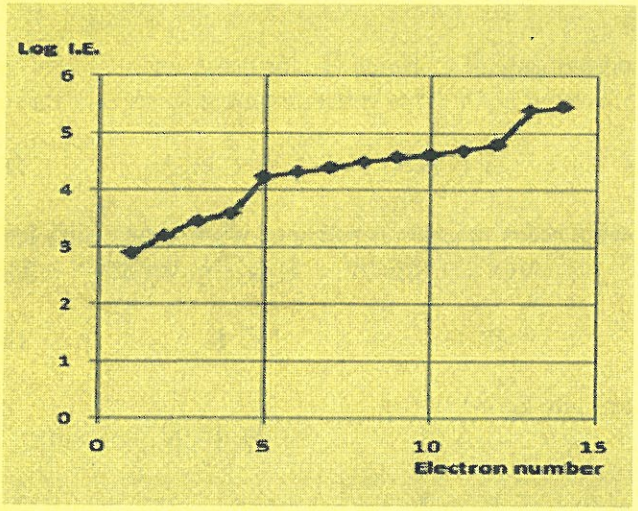
1. Which of the following statements is correct?

A. The oxidation state of Mn in MnO_4^{2-} is +7.
B. The oxidation state of P in $P_2O_7^{4-}$ is +3.
C. The oxidation state of Ba in BaO_2 is +1.
D. The oxidation state of Cr in CrO_4^{2-} is +5.
E. The oxidation state of O in OF_2 is +2.

2. 10.0 g of Zn powder is added into a solution of silver nitrate, $AgNO_3$. The total mass of the metallic solid recovered at the end of the reaction is 12.32 g. Assuming that the reaction did not go to completion, how many grams of Zn did react?

A. 9.0 B. 8.00 C. 5.00 D. 2.00 E. 1.00

3. The following graph shows the logarithm of successive ionization energies (in kJ/mol) as electrons are removed from the atoms of a particular element.



This particular element belongs to which group of the periodic table?

A. 2 B. 3 C. 14 D. 16 E. 18

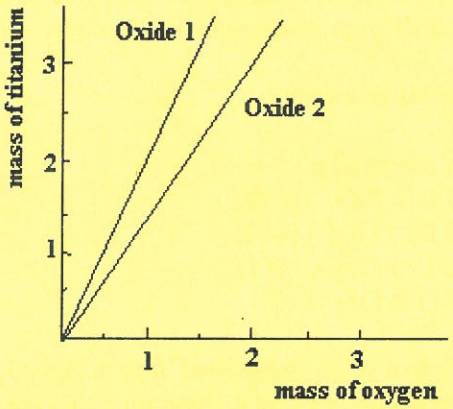
4. Which of the following atoms has the smallest radius?

A. Br B. Cl C. P D. S E. Se

5. How many electrons are described by the following quantum set, $n = 4$; $l = 2$; $m_s = +½$?

A. 5 B. 8 C. 10 D. 16 E. 32

6. A group of researchers did an experiment to determine the mass ratio of titanium to oxygen in two different oxides. Their results are shown below:



From these results it can be deduced the formulae of the two metal oxides are:

	A.	B.	C.	D.	E.
Oxide 1	TiO	Ti_2O	Ti_3O	TiO_2	Ti_2O_3
Oxide 2	Ti_2O_3	Ti_3O	Ti_2O	TiO_3	TiO_2

7. A compound consists only of C, H and N. The combustion of 20.4 mg of this compound releases 44.0 mg of CO_2 and 25.2 mg of H_2O. What is the empirical formula of this compound?

A. C_3H_7N B. $C_3H_7N_2$ C. $C_5H_{10}N$ D. $C_5H_{10}N_2$ E. $C_5H_{14}N_2$

8. When the following redox reaction is balanced what is the coefficient of H_2O?

$$VO^{2+} + MnO_4^- + H_2O \rightarrow V(OH)_4^+ + Mn^{2+} + H^+$$

A. 20 B. 11 C. 8 D. 5 E. 2

9. Convert 1.2 g/cm^3 into kg/m^3.

A. 1.2 B. 0.12 C. 1200 D. 0.012 E. 0.0012

10. Mendeleev's early periodic table was published in 1872. Dmitri Mendeleev named which element "*ekasilicon*"?

A. Al B. Si C. P D. Ge E. Ga

11. Which of the following compounds is NOT correctly named according to IUPAC naming rules?

A. $KAl(SO_4)_2 \bullet 12H_2O$	Potassium aluminum sulfate dodecahydrate
B. $(NH_4)_2Cr_2O_7$	Ammonium dichromate
C. KSCN	Potassium thiocyanate
D. P_4O_{10}	Tetraphosphorus decoxide
E. K_2MnO_4	Potassium permanganate

12. A beaker contains 100.0 mL 0.20 *M* $AgNO_3$ solution (colorless). A second beaker contains 200.0 mL 0.15 *M* K_2CrO_4 solution (yellow). These two solutions are mixed in a third beaker and a precipitate is formed. Which of the following set of statements are CORRECT? (Note: solid potassium nitrate is white and solid silver chromate is red-brown).

The color of the supernatant solution	The color of the precipitate
A. Colorless	Red-Brown
B. Yellow	White
C. Yellow	Red-Brown
D. Colorless	Yellow
E. Yellow	Black

13. Which of the following solutions has the highest concentration of the bromide ion?

A. 400 mL 0.3 *M* NaBr
B. 600 mL 0.2 *M* NaBr
C. 400 mL 0.3 *M* NaBrO
D. 600 mL 0.3 *M* $NaBrO_2$
E. 400 mL 0.2 *M* $NaBrO_3$

14. The chloride impurity in a 2.00 g sample is determined by precipitating the chloride as silver chloride. If 4.80 mL of 0.250 M $AgNO_3$ solution is required, what is the mass percent of chloride in the sample?

A. 6.25 % B. 5.13 % C. 4.52 % D. 3.17 % E. 2.13 %

15. Which of the following transitions is visible to the human eye?

A. n = 6 → n = 4
B. n = 6 → n = 1
C. n = 5 → n = 3
D. n = 4 → n = 2
E. n = 3 → n = 1

16. The organic substitution reactions require the formation of the halogen radical. This is illustrated with the reaction between methane and bromine.

$$Br_2 \rightarrow Br + Br.$$
$$CH_4 + Br \rightarrow CH_3Br + H.$$
$$H. + Br \rightarrow HBr$$

What is the frequency of the visible light that would break the bond between two bromine atoms? Bond energy of Br_2 is 193 kJ/mol.

A. $7.8\times10^{-10}\ s^{-1}$ B. $3.6\times10^{-15}\ s^{-1}$ C. $2.4\times10^{-14}\ s^{-1}$ D. $4.8\times10^{14}\ s^{-1}$ E. $2.9\times10^{38}\ s^{-1}$

17. Which of the following set of solutions will produce the largest mass of precipitate?

A. 10 mL 0.1 *M* $AgNO_3$ + 10 mL 0.2 *M* NaCl
B. 10 mL 0.1 *M* $Pb(NO_3)_2$ + 20 mL 0.1 *M* KI
C. 10 mL 0.1 *M* $AgNO_3$ + 20 mL 0.2 *M* NaCl
D. 10 mL 0.1 *M* $AgNO_3$ + 20 mL 0.1 *M* NaCl
E. 10 mL 0.1 *M* $Pb(NO_3)_2$ + 10 mL 0.1 *M* KI

18. 1.7 g of NH_3 reacts with 3.2 g of O_2 according to the following reaction:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

Assuming that the reaction results in 90% yield, what mass of NO will be produced?

A. 2.2 g B. 2.4 g C. 2.7 g D. 3.0 g E. 3.3 g

19. You want to determine the density of an irregular solid object. Which of the following is NOT needed in determining the density of the object in a high school lab?

A. Eye goggles
B. Balance
C. Graduated cylinder
D. A liquid denser than the object
E. A liquid less dense than the object

20. Mg^{2+} ions can be precipitated with aqueous $(NH_4)_2HPO_4$ and positively identified by a magnesium indicator. What is the formula of the precipitate?

A. $MgHPO_4$
B. Mg_2HPO_4
C. $Mg(HPO_4)_2$
D. $Mg(HPO_3)_3$
E. $Mg_3(PO_4)_2$

21. The equation Al^+ (g) Al^{2+} (g) + e^- represents the _____ energy of aluminum which _____ 1815 kJ/mol.

	First blank	Second blank
A.	First ionization	requires
B.	Second ionization	requires
C.	First electron affinity	requires
D.	Second electron affinity	releases
E.	Second ionization	releases

22. Which of the following compounds is the *least* soluble in water at 20 °C?

A. $Ca(NO_3)_2$ B. KI C. KIO_3 D. $MgCO_3$ E. LiCl

23. 0.250 g of a sample that contains only NaCl (58.5 g/mol) and $CaCl_2$ (111 g/mol) yielded 0.633 g of dried AgCl (143.5 g/mol) when reacted with excess silver nitrate solution. Calculate the percent of NaCl in the mixture.

A. 10.0 % B. 25.0 % C. 40.0 % D. 50.0 % E. 60.0 %

24. Which of the following equations is NOT an oxidation-reduction reaction?

A. $3Cu\ (s) + 8H^+\ (aq) + 8NO_3^-\ (aq) \rightarrow 3Cu^{2+}\ (aq) + 2NO\ (g) + 4H_2O\ (l)$
B. $Cu\ (s) + 2Ag^+\ (aq) \rightarrow Cu^{2+}\ (aq) + 2Ag\ (s)$
C. $Zn\ (s) + 2H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$
D. $SiCl_4\ (l) + 2H_2O\ (l) \rightarrow 4HCl\ (aq) + SiO_2\ (s)$
E. $PbO\ (s) + NH_3\ (g) \rightarrow N_2\ (g) + H_2O\ (l) + Pb\ (s)$

25. The sides of the Al foil are 10.00 cm and 20.00 cm. The thickness of the foil has 4.00×10^4 Al atoms. The diameter of each Al atom is about 2.50×10^2 pm. What is the mass of the Al foil? The density of the Al is 2.73 g/cm^3. Molar mass of Al is 27.0 g/mol.

A.0.273 g B. 0.546 g C. 2.73 g D. 5.46 g E. 0.0546

Chemistry Formulas updated 8-20-2012

CHEMISTRY FORMULAS

GASES, LIQUIDS, SOLUTIONS

$PV = nRT$

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

$P_A = P_{total}\ X_A$

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

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

$Kelvin = {}^\circ C + 273$

$P_1V_1 = P_2V_2$

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

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

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

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

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

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

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

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

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

$\Delta T_f = iK_f \cdot molality$

$\Delta T_b = iK_b \cdot molality$

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

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

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
K = equilibrium constant

R, Gas constant = $\frac{8.31\ joules}{mole \cdot kelvin}$
= $\frac{0.0821\ liter\ atm}{mole\ kelvin}$
= $\frac{8.31\ volts\ coulombs}{mole\ kelvin}$

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

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

STP = 0.00 °C and 1.00 atm (101.3 kpa)

1 faraday $\mathfrak{F}$ = 96,500 coulombs/ mole of electrons

PERIODIC TABLE OF THE ELEMENTS

1 1A																	18 8A
1 H 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (???)				

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	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)	103 Lr (262)

CHEMISTRY FORMULAS 8-20-2012

ATOMIC STRUCTURE

$\Delta E = h\nu$

$c = \nu\lambda$

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

$p = mv$

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

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
Avogador's number = 6.02×10^{23} particles/mole
e = electron charge = -1.602×10^{-19} coulomb
1 electron volt/atom = 96.5×10^{23} kj/mole
1 Angstrom(Å) = 1×10^{-10} meters

OXIDATION-REDUCTION ELECTROCHEMISTRY

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

where $a\,B + b\,B \Leftrightarrow c\,C + d\,D$

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

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

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

1 Faraday $\mathfrak{F}$ = 96,500 coulombs/mole

EQUILIBRIUM

$K_w = 1 \times 10^{-14}$ at 25°C

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

$pH + pOH = 14$

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

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

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

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

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.

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

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

$\ln (k_2/k_1) = (Ea/R)(1/T_1 - 1/T_2)$.

THERMOCHEMISTRY

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

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

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

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

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

$\Delta G^\circ = -n\mathfrak{F}E^\circ$

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

$q = m\,C\,\Delta T$

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

$q = mH_f$

$q = mH_v$.

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 $\mathfrak{F}$ = 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}