Chemistry 106: General Chemistry
Syracuse University Project Advance
Final Exam, Fall 2014

Name:_____ **Date:** _____

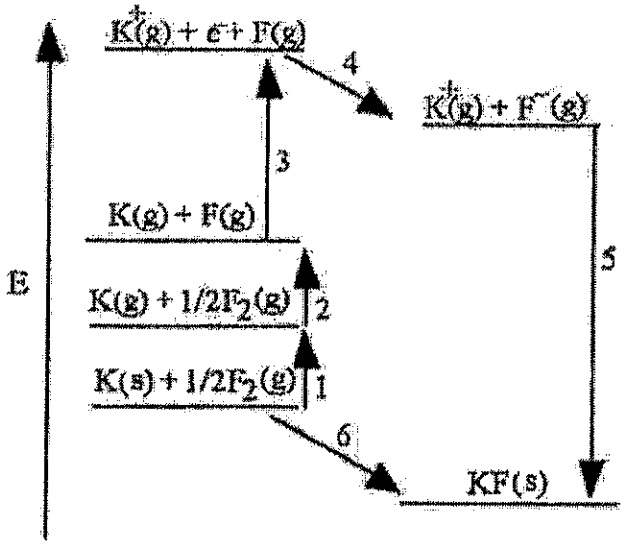
The last pages of the exam are reference tables.

FUNDAMENTAL PHYSICAL CONSTANTS

(values from 2006 CODATA)

Atomic mass unit	1 amu = $1.660538782 \times 10^{-27}$ kg	Molar gas volume, STP	$V_m = 0.022413996$ m³/mol = 22.413996 L/mol
Avogadro's number	$N_A = 6.02214179 \times 10^{23}$ mol^{-1}	Neutron mass	$m_n = 1.674927211 \times 10^{-27}$ kg
Electron (proton) charge	$e = 1.602176487 \times 10^{-19}$ C	Planck's constant	$h = 6.62606896 \times 10^{-34}$ J·s
Electron mass	$m_e = 9.10938215 \times 10^{-31}$ kg	Proton mass	$m_p = 1.672621637 \times 10^{-27}$ kg
Faraday constant	$F = 9.64853399 \times 10^{4}$ C/mol	Speed of light (in vacuum)	$c = 2.99792458 \times 10^{8}$ m/s (exact)
Molar gas constant	R 0.082058 L·atm/(K·mol) 8.3145 J/(K·mol)* 8.3145 kg·m²/(s²·K·mol) 8.3145 kPa·dm³/(K·mol)	Standard acceleration of gravity	$g = 9.80665$ m/s² (exact)

(1) The diagram below is a Born-Haber cycle for the formation of crystalline potassium fluoride. Which energy change shown in the cycle corresponds to the heat of <u>sublimation for potassium?</u>



(A) 1
(B) 6
(C) 4
(D) 5
(E) 2

(2) A mole of the substance (compound) water, H_2O, refers to:

(A) 6.022×10^{23} atoms of H and O
(B) 6.022×10^{23} H_2O molecules
(C) 6.022×10^{23} g H_2O
(D) 12.000 g H_2O
(E) one H_2O molecule

(3) A block of wood has the dimensions of 1.2 m x 5.0 cm x 7.0 cm and has a mass of 3.0 kg. What is the density of the wood? (Note: 1 mL = 1 cm^3)

(A) 0.71 g/mL
(B) 140 g g/mL
(C) 0.071 g/mL
(D) 1400 g/mL
(E) 1.4 g/mL

(4) Choose the INCORRECT name/formula combination.

(A) $NaClO_2$	sodium chlorite
(B) $Sr(IO_3)_2$	strontium iodate
(C) $NaClO_4$	sodium chlorate
(D) SCl_4	sulfur tetrachloride
(E) NaClO	sodium hypochlorite

(5) Maprotiline, a tetracyclic drug prescribed or the treatment of depression, has the following mass composition: C = 86.59%, H = 8.35%, and the rest is nitrogen. What is the empirical formula for maprotiline?

(A) C_3H_3N
(B) $C_7H_8N_3$
(C) $C_{14}H_{14}N$
(D) $C_{20}H_{23}N$
(E) $C_{87}H_8N_5$

(6) From ammonia gas, one can obtain two different gases, each of which is a pure substance. Using ***only*** this information, it can be said with certainty that:

(A) ammonia cannot be an element
(B) one of the products is an element
(C) gases do not produce solids
(D) neither of the products can be an element
(E) both products are elements

(7) What is the frequency (s^{-1}) of electromagnetic radiation that has a wavelength of 0.53 m?

A) 1.6×10^{8}
B) 1.3×10^{33}
C) 1.3×10^{-33}
D) 5.7×10^{8}
E) 1.8×10^{-9}

(8) A species that differs in the charge from another atom of the same element:

I) is called an isotope
II) has more or less neutrons
III) has lost or gained electrons
IV) is called an ion
V) has the same number of protons

(A) I and II
(B) I and III
(C) II and IV
(D) III and IV
(E) III, IV, and V

(9) When the equation $K_2S_2O_3 + I_2 \rightarrow K_2S_4O_6 + KI$ is balanced with the smallest integer coefficients, the coefficient of KI is:

(A) 4
(B) 3
(C) 2
(D) 5
(E) 1

(10) The molecular formula for caffeine is $C_8H_{10}O_2N_4$. How many moles of C atoms are present in a 2.0 g sample of caffeine?

(A) 0.32 mole
(B) 0.082 mole
(C) 0.27 mole
(D) 0.010 mole
(E) 0.041 mole

(11) 42.6 g of copper are combined with 84.0 g of HNO_3 according to the reaction:

$$3\ Cu + 8\ HNO_3 \text{ ------> } 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$$

Which reagent is limiting and what is the theoretical yield of $Cu(NO_3)_2$?
(A) HNO_3, 93.8 g
(B) HNO_3, 125.6 g
(C) Cu, 125.6 g
(D) $Cu(NO_3)_2$, 125.6 g
(E) Cu, 93.8 g

(12) Choose the correct statement.
(A) Neutrons have no change and no mass.
(B) Electrons and protons have about the same mass.
(C) An electron has 1/1837 the mass of a proton.
(D) The atomic number is the total number of protons and neutrons in the nucleus.
(E) The charge of a proton is 1837 times the charge of an electron.

(13) The enthalpy change accompanying the reaction of 0.95 g of S in the flowing reaction is:

$$2\ S(s) + 3\ O_2(g) \text{ ------> } 2\ SO_3(g) \qquad \Delta H° = -790\ kJ$$

(A) -380 kJ
(B) -23 kJ
(C) -47 kJ
(D) -12 kJ
(E) -790 kJ

(14) What are the respective concentrations (M) of Mg^{2+} and $C_2H_3O_2^-$ afforded by dissolving 0.600 mol $Mg(C_2H_3O_2)_2$ in water and diluting to 135 mL?
(A) 0.889 and 0.444
(B) 4.44 and 8.89
(C) 0.0444 and 0.0889
(D) 0.444 and 0.889
(E) 0.444 and 0.444

(15) Which of the following is a weak acid?

(A) HCl
(B) HNO_3
(C) HCN
(D) HI
(E) $HClO_4$

(16) The temperature of a 35.2 g sample of iron increases from 23.7°C to 29.5°C. If the specific heat of iron is 0.450 J/g-K, how many joules of heat are absorbed?

(A) 1.1×10^3
(B) 92
(C) 0.450
(D) 1100
(E) 4.3

(17) An electron cannot have the quantum numbers n = ___ , 1 = _____, and m_l = ____.

(A) 3, 2, 3
(B) 3, 2, 1
(C) 6, 1, 0
(D) 3, 2, -2
(E) 1, 0, 0

(18) What volume (mL) of a concentrated solution of potassium chloride (9.00 M) must be diluted to 350 mL to make a 2.75 M solution of potassium chloride

(A) 2.75
(B) 45.0
(C) 107
(D) 50.0
(E) 350

(19) Which of the following has $\Delta H_f^\circ = 0$?

(A) $CO_2(g)$
(B) Na(s)
(C) $O_2(l)$
(D) $H_2O(l)$
(E) NaCl(aq)

(20) ΔH for the reaction

$$IF_5(g) \text{ ------> } IF_3(g) + F_2(g)$$

is _____ kJ, given the data below.

$IF(g) + F_2(g)$ ------> IF_3 $\Delta H = -390$ kJ
$IF(g) + 2\ F_2(g)$ ------> $IF_5(g)$ $\Delta H = -745$ kJ

(A) +1135
(B) +35
(C) -35
(D) -1135
(E) +355

(21) In a hydrogen atom, an electron in a _____ orbital can absorb a photon, but cannot emit a photon.
(A) 3p
(B) 3f
(C) 1s
(D) 3s
(E) 2s

(22) The net ionic equation for the reaction between aqueous hydrochloric acid and aqueous sodium hydroxide is _____.
(A) $HCl(aq) + OH^-(aq)$ ------> $Cl^-(aq) + H_2O(l)$
(B) $H^+(aq) + HCl(aq) + 2\ OH^-(aq)$ ------> $2\ H_2O(l) + Cl^-(aq)$
(C) $H^+(aq) + Na^+(aq) + OH^-(aq)$ -------> $H_2O(l) + Na^+(aq)$
(D) $H^+(aq) + OH^-(aq)$ ------> $H_2O(l)$
(E) $HCl(aq) + NaOH(aq)$ ------> $NaCl(aq) + H_2O(l)$

(23) A _____ ΔH corresponds to an _____ process.
(A) positive, exothermic
(B) zero, exothermic
(C) zero, endothermic
(D) positive, endothermic
(E) large magnitude, exothermic

(24) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction is _____ kJ.

$Ca(OH)_2(aq) + 2\ H_3AsO_4(aq)$ ------> $Ca(H_2AsO_4)_2(aq) + 2\ H_2O(l)$

Substance	$\Delta H°_f$ (kJ/mol)
$Ca(OH)_2(aq)$	-986.6
$H_3AsO_4(aq)$	-900.4
$Ca(H_2AsO_4)_2(aq)$	-2346.0
$H_2O(l)$	-285.9

(A) -4219
(B) -744.9
(C) -4519
(D) -130.4
(E) -76.4

(25) The ground-state electron configuration of _____ is $[Ar]4s^1 3d^5$.
(A) V
(B) Mn
(C) K
(D) Cr
(E) Fe

(26) What is the oxidation number of S in SO_2?
(A) 0
(B) -2
(C) +4
(D) -4
(E) +2

(27) The first ionization energies of the elements _____ as you go from left to right across a period of the periodic table, and _____ as you go from the bottom to the top of a group in the table.
(A) increase, increase
(B) increase, decrease
(C) decrease, increase
(D) decrease, decrease
(E) follow no clear pattern, are completely unpredictable

(28) Electrons in the 1s subshell are much closer to the nucleus in Ar than in He due to the larger _____in Ar.

(A) angular momentum quantum number
(B) Hund's rule
(C) paramagnetism
(D) nuclear charge
(E) diamagnetism

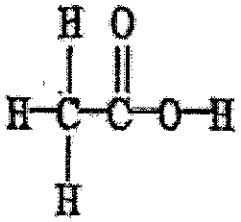
(29) The hybridization of carbon in the HCN molecule is _____.

(A) s^2p
(B) sp^3
(C) sp^2
(D) s^3p
(E) sp

(30) The O-S-O bond angle in SO_2 is slightly less than _____.

(A) 109.5°
(B) 180°
(C) 90°
(D) 120°
(E) 60°

(31) The geometry of the right-most carbon in the molecule below is _____.



(A) T-shaped
(B) tetrahedral
(C) trigonal pyramidal
(D) trigonal planar
(E) octahedral

(32) Which of the following is an isoelectronic series?

(A) B^{5-}, Si^{4-}, As^{3-}, Te^{2-}
(B) Si^{2-}, P^{2-}, S^{2-}, Cl^{2-}
(C) O^{2-}, F^-, Ne, Na^+
(D) F^-, Cl^-, Br^-, I^-
(E) S, Cl, Ar, K

(33) The basis of the VSEPR model of molecular bonding is _____.

(A) electron domains in the valence shell of an atom will arrange themselves so as to minimize repulsions.
(B) atomic orbitals of the bonding atoms must overlap for a bond to form.
(C) regions of electron density on an atom will organize themselves so as to maximize s-character.
(D) hybrid orbitals form as necessary to, as closely as possible, achieve spherical symmetry.
(E) regions of electron density in the valence shell of an atom will arrange themselves so as to maximize overlap.

(34) The blending of one s atomic orbital and two p atomic orbitals produces _____.

(A) three sp^3 hybrid orbitals.
(B) two sp^2 hybrid orbitals.
(C) two sp^3 hybrid orbitals.
(D) three sp^2 hybrid orbitals.
(E) three sp hybrid orbitals.

(35) The central iodine atom in ICl_4^- has _____ non-bonded electron pairs and _____ bonded electron pairs in its valence shell.

(A) 2, 4
(B) 1, 3
(C) 3, 2
(D) 2, 2
(E) 3, 4

(36) Of the molecules below, only _____ is polar.

(A) I_2
(B) SF_6
(C) CH_4
(D) SbF_5
(E) AsH_3

(37) The reason that He diffuses faster than carbon monoxide, CO, is that He atoms are _____ than CO molecules.
(A) lighter
(B) less reactive
(C) more spherical
(D) smaller
(E) less polar

(38) How many moles of gas are there in a 50.0 L container at 22.0°C and 825 torr?
(A) 18.4
(B) 2.29×10^4
(C) 0.603
(D) 1.70×10^3
(E) 2.24

(39) Of the following, which is a correct statement of Boyle's law?
(A) n/P = constant
(B) V/P = constant
(C) P/V = constant
(D) PV = constant
(E) V*T = constant

(40) A flask contains a mixture of He and Ne at a total pressure of 2.6 atm. There are 2.0 mol of He and 5.0 mol of Ne in the flask. The partial pressure of He is _____ atm.
(A) 1.86
(B) 0.74
(C) 6.5
(D) 9.1
(E) 1.04

(41) Which of the following compounds is chromium(III) oxide?
(A) Cr_3O
(B) Cr_3O_2
(C) Cr_2O_3
(D) Cr_2O_4
(E) CrO_3

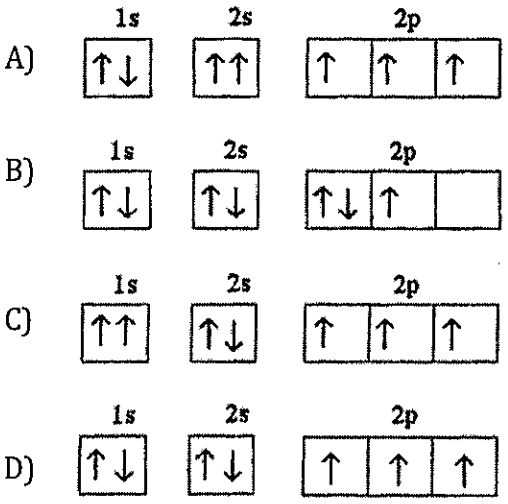
(42) The complete combustion of 1 mole of nitrobenzene, $C_6H_5HO_2$, in a bomb calorimeter liberates 3088 kJ of heat and increases the temperature of the calorimeter assembly by 140.0°C. What is the heat capacity of this bomb calorimeter?

(A) 1.25 kJ/°C
(B) 22.1 kJ/°C
(C) 432 kJ/°C
(D) 43.1 kJ/°C
(E) 4.53 kJ/°C

(43) A triple bond consists of _____.

(A) two sigma and one pi bond
(B) three sigma bonds
(C) three pi bonds
(D) one sigma and two pi bonds
(E) three ionic bonds

(44) Which one of the following is the correct electron configuration for a ground-state nitrogen atom?



E) None of the above is correct

(45) When NaCl dissolves in water, the force of attraction that exists between Na^+ and H_2O is called:

(A) dipole-dipole
(B) ion-ion
(C) hydrogen bonding
(D) ion-dipole
(E) none of the above

(46) The intermolecular force(s) responsible for the fact that H_2O has the highest boiling point in the series H_2O, H_2S, H_2Se, H_2Te is/are
(A) hydrogen bonding
(B) dipole-dipole interactions
(C) London-dispersion forces
(D) mainly hydrogen bonding but also dipole-dipole interactions
(E) mainly London-dispersion forces but also dipole-dipole interactions

(47) 24.2 g of a gas initially at 4.00 atm is compressed from 8.00 L to 2.00 L at constant temperature. What is the resulting pressure in atm of the gas?
(A) 4.00
(B) 2.00
(C) 1.00
(D) 8.00
(E) 16.0

EXTRA CREDIT – SHOW ALL WORK

A 0.920 gram sample of magnesium is allowed to burn in 0.321 g of oxygen gas. The sole product of the reaction is magnesium oxide. After the reaction, no oxygen remains and 0.809 g of magnesium oxide has been formed. What mass of magnesium is left unreacted?
(A) 0.432 g
(B) 0.210 g
(C) 0.488 g
(D) 1.408 g
(E) 0.111 g

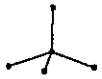
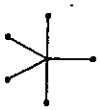
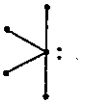
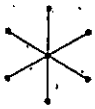
TABLE 4.1 Solubility Guidelines for Common Ionic Compounds in Water

Soluble Ionic Compounds		Important Exceptions
Compounds containing	NO_3^-	None
	$C_2H_3O_2^-$	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	Br^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	I^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Ionic Compounds		**Important Exceptions**
Compounds containing	S^{2-}	Compounds of NH_4^+, the alkali metal cations, and Ca^{2+}, Sr^{2+}, and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of the alkali metal cations, and Ca^{2+}, Sr^{2+}, and Ba^{2+}

TABLE 4.5 Activity Series of Metals in Aqueous Solution

Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
Calcium	$Ca(s) \longrightarrow Ca^{2+}(aq) + 2e^-$
Sodium	$Na(s) \longrightarrow Na^+(aq) + e^-$
Magnesium	$Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$
Aluminum	$Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$
Manganese	$Mn(s) \longrightarrow Mn^{2+}(aq) + 2e^-$
Zinc	$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
Chromium	$Cr(s) \longrightarrow Cr^{3+}(aq) + 3e^-$
Iron	$Fe(s) \longrightarrow Fe^{2+}(aq) + 2e^-$
Cobalt	$Co(s) \longrightarrow Co^{2+}(aq) + 2e^-$
Nickel	$Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^-$
Tin	$Sn(s) \longrightarrow Sn^{2+}(aq) + 2e^-$
Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^-$
Hydrogen	$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$
Copper	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Silver	$Ag(s) \longrightarrow Ag^+(aq) + e^-$
Mercury	$Hg(l) \longrightarrow Hg^{2+}(aq) + 2e^-$
Platinum	$Pt(s) \longrightarrow Pt^{2+}(aq) + 2e^-$
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Molecular Structure

# of σ Bonds	# of Non-Bonding Pairs	Molecular Shape	
2	0		Linear
3	0		Trigonal planar
2	1		Angular, Bent
4	0		Tetrahedral
3	1		Trigonal pyramidal
2	2		Angular, Bent
5	0		Trigonal bipyramidal
4	1		Sawhorse (irregular tetrahedron) seesaw
3	2		T-shaped
2	3		Linear
6	0		Octahedron
5	1		Square pyramidal
4	2		Square planar

Periodic Table of the Elements

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.012											5 B 10.81	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 24.31											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.056	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.955	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
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	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	[107] Bh (262)	[108] Hs (265)	[109] Mt (268)									

Lanthanide Series	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	71 Lu 174.96
Actinide Series	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	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 (260)