Chemistry 1E03 ***Test 2*** ***Nov. 11, 2016***

McMaster University ***VERSION 1***

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Duration: 120 minutes

This test contains 19 numbered pages printed on both sides. There are **25** multiple-choice questions appearing on pages numbered 3 to 15. Pages 16 and 17 provide extra space for rough work. Page 18 includes some useful data and equations, and there is a periodic table on page 19. You may tear off the last pages to view the periodic table and the data provided.

You must enter your name and student number on this question sheet, as well as on the answer sheet. Your invigilator will be checking your student card for identification.
You are responsible for ensuring that your copy of the question paper is complete. Bring any discrepancy to the attention of your invigilator.

All questions are worth 1 mark; the total marks available are 25. There is **no** additional penalty for incorrect answers.

BE SURE TO ENTER THE CORRECT VERSION NUMBER OF YOUR TEST (shown near the top of page 1), IN THE SPACE PROVIDED ON THE ANSWER SHEET.

ANSWER ALL QUESTIONS ON THE ANSWER SHEET, IN PENCIL.
Instructions for entering multiple-choice answers are given on page 2.
SELECT ONE AND ONLY ONE ANSWER FOR EACH QUESTION from the answers **(A)** through **(E). No work written on the question sheets will be marked**. The question sheets may be collected and reviewed in cases of suspected academic dishonesty.

Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, *etc*.) between students, sharing of materials between students, copying or looking at other students' work. If you have a problem please ask the invigilator to deal with it for you. Do not make contact with other students directly. Keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy answers.

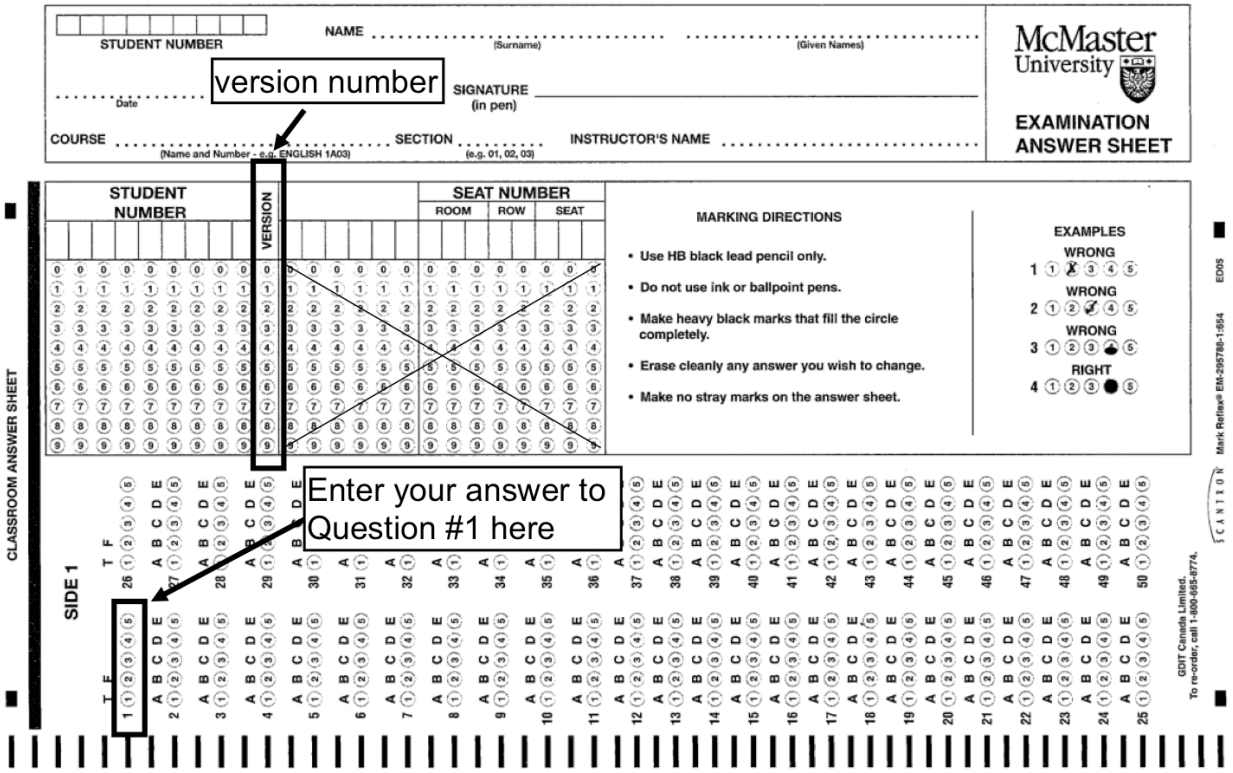
Only Casio FX 991 electronic calculators may be used; but they must NOT be transferred between students. Use of periodic tables or any aids, other than those provided, is not allowed.

OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: YOUT EXAMINIATION RESULT DEPENDS UPON PROPER ATTENTION TO THESE INSTRUCTIONS.

The scanner, which reads the sheets, senses the bubble shaded areas by their non-reflection of light. A heavy mark must be made, completely filling the circular bubble, with an HB pencil. Marks made with a pen will **NOT** be sensed. Erasures must be thorough or the scanner will still sense a mark. Do **NOT** use correction fluid on the sheets. Do **NOT** put any unnecessary marks or writing on the sheet.

1. On SIDE 1 (**red side**) of the form, in the top box, *in pen*, print your student number, name, course name, and the date in the spaces provided. Then you **MUST** write your signature, in the space marked SIGNATURE.
2. In the second box, *with a pencil*, mark your student number, **exam version number** in the space provided and **fill in the corresponding bubble numbers underneath**.
3. Answers: mark only **ONE** choice from the alternatives (A,B,C,D,E) provided for each question. The question number is to the left of the bubbles. Make sure that the number of the question on the scan sheet is the same as the number on the test paper.
4. Pay particular attention to the Marking+ Directions on the form.
5. Begin answering the question using the first set of bubbles, marked "1".



1. It takes 492 kJ of energy to remove one mole of electrons from the atoms on the surface of solid gold. What is the maximum wavelength (in nm) capable of doing this?

A) 123
B) 243
C) 404
D) 743
E) 817

2. Which one of the atoms listed below is described by **all** of the following statements?

(i) The ground state of the atom has p electrons in the valence shell.
(ii) The ground state of the atom contains at least one unpaired electron.
(iii) The atom has a smaller atomic radius than magnesium.
(iv) The atom has a larger ionization energy than phosphorus.

A) Si
B) Be
C) Na
D) Cl
E) Rb

3. Consider the following equilibrium:

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad \Delta H = -198.2\ kJ\ mol^{-1}$$

Which of the following changes does **not** cause the partial pressure of $SO_2(g)$ to **increase**?

A) The temperature is increased.
B) An inert gas is added to increase the total pressure – the volume does not change.
C) The volume is increased.
D) O_2 is removed.
E) SO_3 is added.

4. A reaction vessel, at 500 K, contains 1.000 bar $PCl_5(g)$, 0.705 bar $PCl_3(g)$ and 0.705 bar $Cl_2(g)$ – all in equilibrium. Determine the **equilibrium constant** K_P for the reaction,

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A) 0.497
B) 0.558
C) 9.71
D) 0.865
E) −1.41

5. The equilibrium constant for the reaction

$$N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g)$$

is $K_p = 1.7 \times 10^{-1}$ at an elevated temperature. A reaction vessel at this temperature contains these gases with the following partial pressures:

Gas	Partial Pressure
$N_2(g)$	0.25 bar
$O_2(g)$	0.25 bar
NO(g)	4.2×10^{-1} bar

Which of the following statements is **true**?

A) $Q > K$, and the reaction proceeds to the reactants side.
B) $Q > K$, and the reaction proceeds to the products side.
C) The system is at equilibrium.
D) $Q < K$, and the reaction proceeds to the products side.
E) $Q < K$, and the reaction proceeds to the reactants side.

6. Consider a 100. mL aqueous solution of lead(II) chloride with an unknown concentration – this is the sample solution. A test solution, 1.00×10^{-1} mol L^{-1} aqueous solution of sodium chloride, is dripped into the sample solution. A precipitate first forms after 13.7 mL of test solution is added to the sample solution. What is the **unknown lead(II) chloride concentration** in mol L^{-1}? $K_{sp}[PbCl_2] = 1.7 \times 10^{-5}$.

A) 0.17
B) 0.0031
C) 0.12
D) 0.072
E) 0.053

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7. Which of the following is **not a product** of one of the reactions in the cycles of copper laboratory?

A) $Cu(NO_3)_2(aq)$, blue/green solution
B) $CuSO_4(s)$, blue/green precipitate
C) $CuO(s)$, black precipitate
D) $Cu(OH)_2(s)$, blue precipitate
E) $NO_2(g)$, brown gas

8. How much **heat**, in **kJ**, is required to warm 63.0 g of liquid ethylene glycol (specific heat capacity = 2.20 J g^{-1} K^{-1}) from 20.0°C to 40.0°C?

A) 1.64
B) 6.11
C) 3.91
D) 5.14
E) 2.77

9. In an insulated bomb calorimeter, 0.568 g of solid citric acid ($C_6H_8O_7$, molar mass 192.12 g/mol) was completely combusted, at 25.00 °C. The calorimeter contained 1032 g of water, initially at 25.00 °C. The temperature of the water was observed to rise to 26.36 °C. Assume all the heat of the reaction went into heating the water, and that the heat capacity of water is 4.18 J g^{-1} K^{-1}. Calculate the **molar energy change (in kJ mol^{-1}) for combustion** of citric acid.

A) –487
B) –1851
C) 1980
D) 487
E) –1980

10. For which of the following reactions is heat **released** by the system ($q < 0$), and work is done **by** the system ($w < 0$)?

A) $Cl_2(g) \rightarrow 2\ Cl(g)$
B) $H_2O(g) \rightarrow H_2O(l)$
C) $2\ Na(s) + 2\ H_2O(l) \rightarrow 2\ NaOH(aq) + H_2(g)$
D) $Pb(s) \rightarrow Pb(l)$
E) $Br_2(l) \rightarrow Br_2(g)$

11. What is the standard enthalpy of **formation** of $PCl_3(g)$ (in kJ mol^{-1})? (Note that $P_4(s)$ is the standard state of phosphorus.)

Data:

$P_4(s) + 10\ Cl_2(g) \rightarrow 4\ PCl_5(s)$ $\quad\quad \Delta H° = -1774.0$ kJ mol^{-1}

$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(s)$ $\quad\quad \Delta H° = -156.5$ kJ mol^{-1}

A) –1623
B) +1623
C) +287
D) –287
E) –491

12. The standard enthalpy of formation for acetylene (gas), H-C≡C-H, is +226.7 kJ mol^{-1}. The average bond enthalpy for a carbon-carbon triple bond (C≡C) is 837 kJ mol^{-1} and the average bond enthalpy of a C-H bond is 414 kJ mol^{-1}. The bond enthalpy for H_2 is 436 kJ mol^{-1}. Estimate the **enthalpy of sublimation of graphite**, in kJ mol^{-1}; i.e., $\Delta H°$ for $C(s) \rightarrow C(g)$.

A) 728
B) 1411
C) 1096
D) 571
E) 401

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13. Use the following data to calculate the **second electron affinity** (in kJ mol^{-1}) of oxygen**,** i.e., the **enthalpy change** for the reaction, $O^-(g) + e^- \rightarrow O^{2-}(g)$.

Lattice energy of Na_2O = –2481 kJ mol^{-1}
Formation enthalpy of $Na_2O(s)$ = –279.3 kJ mol^{-1}
Sublimation enthalpy of Na = +107.76 kJ mol^{-1}
First ionization energy of Na = +500. kJ mol^{-1}
Formation enthalpy of O(g) = +249.2 kJ mol^{-1}
Electron affinity of O(g) = –141 kJ mol^{-1}

A) –1297
B) 911
C) 1392
D) 878
E) –201

14. How many **charge-minimized resonance structures** are required to describe the bonding in the HPO_4^{2-} anion? (P is the central atom, and is bonded only to O).

A) 1
B) 2
C) 3
D) 4
E) 6

15. For the molecule $ClNO_2$ nitrogen is the central atom, and all other atoms are bonded to N. In its charge-minimized Lewis structure, the **central N** atom has:

A) 4 bonding pairs of electrons.
B) 5 bonding pairs of electrons.
C) 1 lone pair and 3 bonding pairs of electrons.
D) 1 lone pair and 4 bonding pairs of electrons.
E) 2 lone pairs and 3 bonding pairs of electrons.

16. Considering the charge-minimized resonance structures, what is the **average formal charge** on an oxygen atom in phosphate, PO_4^{3-}?

A) - 0.5
B) - 0.75
C) - 1
D) - 1.5
E) - 2

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17. How many **non-bonding electrons** are there in the charge-minimized Lewis structure for nitric oxide, NO_2 ? (In the Lewis structure, N is the central atom).

A) 14
B) 9
C) 6
D) 11
E) 18

18. What is the shape of PCl_3 ?

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

19. Which of the following rankings of the molecules AsF_5, AsF_3 and AsH_3, in order of increasing molecular dipole moment, is **CORRECT**?

(Electronegativity values: F = 4.0; As = 2.0; H = 2.1)

A) $AsF_5 < AsF_3 < AsH_3$
B) $AsH_3 < AsF_5 < AsF_3$
C) $AsF_5 < AsH_3 < AsF_3$
D) $AsF_3 < AsF_5 < AsH_3$
E) $AsH_3 < AsF_3 < AsF_5$

20. Which **one** of the following reactions is an oxidation-reduction reaction?

A) $NaOCl(aq) + CO(g) \rightarrow NaCl(aq) + CO_2(g)$
B) $SiCl_4(l) + 2\ H_2O(l) \rightarrow 4\ HCl(aq) + SiO_2(s)$
C) $SrCO_3(s) \rightarrow SrO(s) + CO_2(g)$
D) $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$
E) $NaNH_2(s) + 2\ HBr(aq) \rightarrow NaBr(aq) + NH_4Br(aq)$

21. Complete and balance the following reaction with the smallest integer coefficients in *aqueous* media. Determine the stoichiometric coefficient of hydroxide (OH^-).

$$I^-(aq) + O_2(g) \rightarrow I_2(s) + OH^-(aq)$$

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

22. In the following **disproportionation** reaction phosphorus produces phosphine ($PH_3(g)$) and hypophosphite ($H_2PO_2^-(aq)$). When the reaction is **balanced in basic solution** and the stoichiometric coefficients have been reduced to the **lowest integer values**, what is the **coefficient of $OH^-(aq)$**? (In a disproportionation reaction one species is simultaneously oxidized and reduced).

$$P_4(s) \rightarrow PH_3(g) + H_2PO_2^-(aq)$$

A) 2
B) 3
C) 4
D) 6
E) 12

23. Which one of the following reactions is **NOT an acid-base** reaction?

A) $NaOH(aq) + HCl(aq) \rightarrow H_2O(l) + NaCl(aq)$
B) $HNO_3(aq) + NH_3(aq) \rightarrow NH_4NO_3(aq)$
C) $NaCH_3COO(aq) + H_2O(l) \rightarrow NaOH(aq) + CH_3COOH(aq)$
D) $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$
E) $HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$

24. Which of the following reactant pairs is most likely to undergo a **precipitation** reaction?

A) $Cu(s) + HBr(aq) \rightarrow ?$
B) $Cl_2(aq) + KBr(aq) \rightarrow ?$
C) $HClO_3(aq) + NH_3(aq) \rightarrow ?$
D) $CaCl_2(aq) + Na_3PO_4(aq) \rightarrow ?$
E) $KOH(aq) + Li(NO_3)_2(aq) \rightarrow ?$

25. In the third experiment for Chem 1E03, the *K* value for the following reaction was determined. Which of the factors below would not cause a potential discrepancy in the experimentally determined value of *K*?

$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$

A) Using initial (known) concentrations of Fe^{3+} and SCN^{-} different from the lab protocol values.
B) Temperature
C) The precision of the spectrometer.
D) Not calibrating the spectrometer before each trial.
E) Unknowingly using the wrong concentration of Fe^{3+}.

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Extra space for rough work:

Extra space for rough work:

- **Some general data are provided on this page.**
- **A Periodic Table with atomic weights is provided on the next page.**

$R = 8.3145\ \text{J K}^{-1}\ \text{mol}^{-1} = 0.08314\ \text{L bar K}^{-1}\ \text{mol}^{-1}$

$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$c = 2.9979 \times 10^{8}\ \text{m s}^{-1}$

$h = 6.6256 \times 10^{-34}\ \text{Js}$

$m_e = 9.10 \times 10^{-31}\ \text{kg}$

1 bar = 100.0 kPa

0°C = 273.15 K

$1\ \text{J} = 1\ \text{kg m}^2\ \text{s}^{-2} = 0.01\ \text{L bar} = 1\ \text{Pa m}^3$

$1\ \text{m} = 10^9\ \text{nm} = 10^{10}\ \text{Å}$

$1\ \text{cm}^3 = 1\ \text{mL}$

$1\ \text{g} = 10^3\ \text{mg}$

1 Hz = 1 cycle/s

De Broglie wavelength:

$\lambda = h / mv = h / p$

Hydrogen atom energy levels:

$E_n = -R_H / n^2 = -2.178 \times 10^{-18}\ \text{J} / n^2$

Density of water:

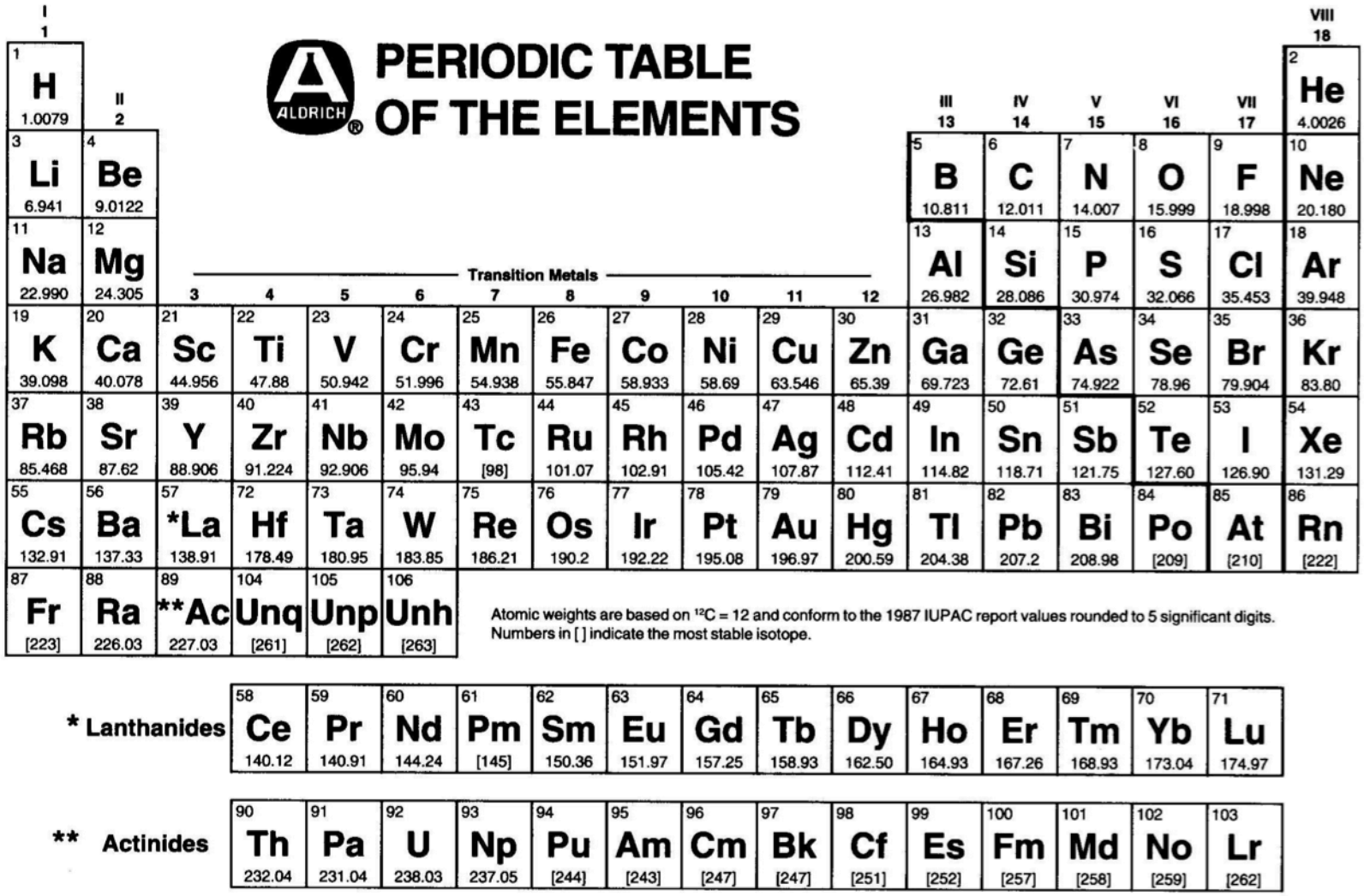
$1.00\ \text{g mL}^{-1}$

Specific heat capacity of water:

$4.18\ \text{J K}^{-1}\ \text{g}^{-1}$

Solubility Guidelines for Common Ionic Solids

1. Alkali metal and ammonium salts are *soluble*.
2. Nitrate, chlorate, perchlorate, hydrogen carbonate and ethanoate salts are *soluble*.
3. Sulfate salts are *soluble*, *except* for the calcium, strontium, barium and lead salts which are *insoluble*.
4. Chloride, bromide and iodide salts are *soluble*, *except* for the silver, lead and mercury I salts which are *insoluble*.
5. Silver, lead and mercury I salts are *insoluble*, unless deemed soluble by rule 2 or 3.
6. Sulfide salts are *insoluble*, *except* for the alkali metal, ammonium, and alkaline earth salts which are *soluble*.
7. Oxide and hydroxide salts are *insoluble*, *except* for the alkali metal, ammonium, calcium, strontium and barium salts which are soluble.
8. Carbonate and phosphate are *insoluble*, *except* for the alkali metal and ammonium salts.



I 1	II 2											III 13	IV 14	V 15	VI 16	VII 17	VIII 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 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	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 69.723	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 105.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	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 Unq [261]	105 Unp [262]	106 Unh [263]												

* Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.97	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 174.97
** Actinides	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 [262]

END OF TEST