Name: ____________________ **Student number:** ______________

Chemistry 1E03 **Deferred Exam** **February 2015**

McMaster University ***VERSION 1***

Instructors: Drs. R.S. Dumont, P. Kruse & J. Landry

Duration: 180 minutes

This test contains xx numbered pages printed on both sides. There are **35** multiple-choice questions appearing on pages numbered 3 to 21. Pages 20 and 21 provide extra space for rough work. Page 22 includes some useful data and equations, and there is a periodic table on page 23. 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 35. 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.

<u>ANSWER ALL QUESTIONS</u> ON THE ANSWER SHEET, IN PENCIL.
Instructions for entering multiple-choice answers are given on page 2.
SELECT <u>ONE AND ONLY ONE</u> 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. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy.

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.

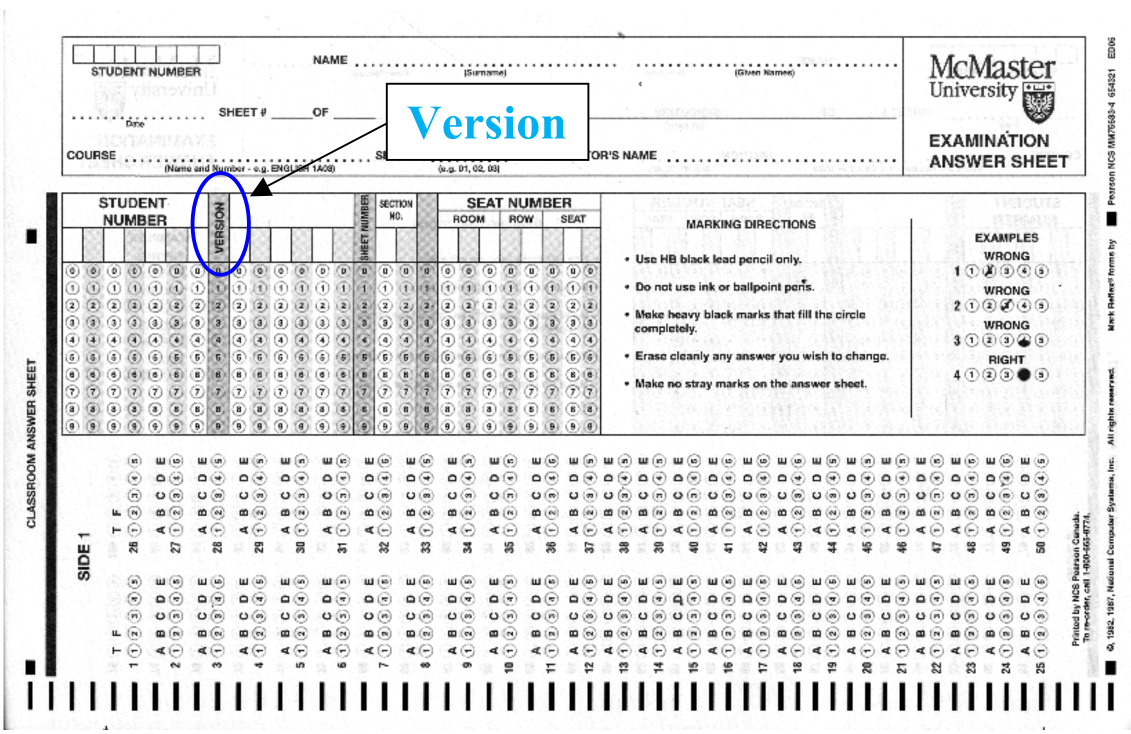
Name: ____________________ Student number: ______________

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 <u>fill in the corresponding bubble numbers underneath</u>.
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. 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) 6
B) 4
C) 2
D) 12
E) 3

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

(i) The atom contains p electrons in its 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) Cl
B) Si
C) Rb
D) Na
E) Be

 Continued on next page

3. Consider the following equilibrium:

$$A\ (g) + B\ (g) \rightleftharpoons 2\ C\ (g) \qquad K = 24.3$$

Initially, A and B are added together (with no C present) with **equal** partial pressures. When equilibrium is reached, the pressure of C is measured to be 2.4 bar. What was the **initial partial pressure** of **A** and **B**?

.

A) 2.0 bar
B) 3.5 bar
C) 1.7 bar
D) 0.84 bar
E) 1.2 bar

4. Which **one** of the following species has the **shortest Br-O bonds**?

.

A) BrO_3^-
B) $BrF_2O_2^-$
C) BrO_4^-
D) BrO_2^-
E) BrO^-

 Continued on next page

5. **Which** of the following **pairs** of reagents will form a **precipitate** when mixed?

   (i) $NaCl(aq) + MgBr_2(aq)$
   (ii) $KNO_3(aq) + CuSO_4(aq)$
   (iii) $MgCl_2(aq) + K_3PO_4(aq)$
   (iv) $CaClO_4(aq) + Na_2CO_3(aq)$
   (v) $NH_4Cl(aq) + Li_2CrO_4\ (aq)$
   .
   A) ii , iii and iv
   B) i only
   C) iv only
   D) iii and v
   E) iii and iv

6. Which of the following statements are **FALSE** about BrO_2F (Br is the central atom)?

   (i) It has a permanent dipole moment.
   (ii) It is T-shaped about Br.
   (iii) There is one lone pair of electrons on Br.
   (iv) The octet rule is violated at Br.
   (v) The oxidation number of Br is +5.
   (vi) The average Br-O bond order is 1.5.
   .
   A) iii, iv
   B) ii, vi
   C) i, v
   D) ii, iv
   E) iv, vi

 Continued on next page

7. A vessel is filled with $N_2O_4(g)$ to an initial partial pressure of 3.01 bar. Some of this gas decomposes into $NO_2(g)$. At equilibrium, the partial pressure of $N_2O_4(g)$ is found to be 2.71 bar. What is the **total pressure** of the gas mixture at equilibrium (in bar)?

.

A) 3.31
B) 2.77
C) 2.99
D) 0.133
E) 3.06

8. **How many** 4p atomic **orbitals** are there?

.

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

 Continued on next page

9. A 150.0 g sample of a metal at 80.00°C is placed in 100 ml of pure water at 20.00°C. The final temperature of the system (metal + water) is 23.30°C. What is the **specific heat capacity** of the metal, in J g^{-1} K^{-1}?
.
A) -0.039
B) +0.162
C) –194
D) +0.002
E) +0.039

10. What is the **enthalpy change** (in kJ mol^{-1}) of the following gas-phase reaction? (Hint: write the Lewis structures of the molecules before using the given bond enthalpies.)

$$2\ C_2H_4(g) \rightarrow C_2H_2(g) + C_2H_6(g)$$

Bond enthalpies (kJ mol^{-1}): C-C 348; C=C 619; C≡C 812; C-H 413
.
A) –78
B) +49
C) –126
D) +78
E) –49

11. A gas does 135 J of work while expanding and, at the same time, absorbs 156 J of heat. What is its **change in energy**, ΔU (in J)?
.
A) +291
B) cannot be calculated unless ΔT is given.
C) +21
D) –21
E) –291

12. Select the one **FALSE** statement:
.
A) $2\ O(g) \rightarrow O_2(g)$ is an exothermic reaction.
B) $\Delta H°_f(O_3(g)) = 0$
C) At 298K the standard state of the element oxygen is $O_2(g)$.
D) Bond energies are always positive.
E) The condensation of water [$H_2O(g) \rightarrow H_2O(l)$] is an exothermic process.

 Continued on next page

13. Use the following data to calculate the **electron affinity of O^-(g),** *i.e.* the **enthalpy change**, for the reaction: O^- (g) + e^- → 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) +1210. kJ mol^{-1}
B) +878 kJ mol^{-1}
C) –1416 kJ mol^{-1}
D) –878 kJ mol^{-1}
E) +1416 kJ mol^{-1}

14. The standard enthalpy of formation ethyne (acetylene) gas, C_2H_2(g), is +226 kJ mol^{-1}. Under pressure, ethyne can react with itself to form liquid benzene, C_6H_6(l), whose standard enthalpy of formation is +49 kJ mol^{-1}.
Determine the **enthalpy of reaction** (in kJ mol^{-1}) for formation of benzene from ethyne.
.

A) –629
B) –210
C) –727
D) –275
E) –197

15. Consider the proposed reaction $H_2(g) + S(s) \rightarrow H_2S(g)$ for which $\Delta H° = –20$ kJ mol^{-1} and $\Delta S° = +43$ J K^{-1}mol^{-1}, at 298 K. Choose the **ONE TRUE** statement.
.
A) The reaction in not spontaneous at any temperature.
B) The reaction is spontaneous only above a temperature of 465 K.
C) The reaction is spontaneous at all temperatures.
D) The reaction is not spontaneous at 298 K.
E) The reaction is driven by enthalpy only.

16. Given the following data, calculate $\boldsymbol{\Delta G°}$ (in kJ mol^{-1}) for the reaction:

$$2\,C(s) + H_2(g) \rightarrow C_2H_2(g)$$

$C_2H_2(g) + 5/2\,O_2(g) \rightarrow 2\,CO_2(g) + H_2O(l)$ $\Delta G° = –1234$ kJ mol^{-1}
$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta G° = –394$ kJ mol^{-1}
$H_2(g) + ½\,O_2(g) \rightarrow H_2O(l)$ $\Delta G° = –237$ kJ mol^{-1}

A) +603
B) +209
C) -603
D) -1865
E) +366

 Continued on next page

17. Use the following data to determine **$\Delta G_f°$ of HBr(g)** (in kJ mol^{-1}) at 25.00°C.

Data:

	$\Delta H_f°$ / (kJ mol^{-1})	$S°$ / (J $K^{-1}mol^{-1}$)
$H_2(g)$	0	130.684
$Br_2(l)$	0	152.2
HBr(g)	–36.40	198.695

.
A) –72.5
B) –19.0
C) –116.3
D) –53.5
E) –38.3

18. Identify the **FALSE** statement(s) from among the following:

(i) For any chemical reaction, $\Delta G° < \Delta H°$.
(ii) The endothermic dissolution of $NH_4NO_3(s)$ in water is driven by entropy.
(iii) For a chemical reaction at equilibrium at temperature T, $\Delta H = T\Delta S$.

.
A) i, ii
B) ii, iii
C) ii
D) i
E) iii

 Continued on next page

19. When NH_3(g) reacts **spontaneously** with HCl(g), solid NH_4Cl(s) is formed. This is accompanied by the following **changes**:

.

A) $\Delta G > 0$, $\Delta H < 0$, $\Delta S < 0$
B) $\Delta G < 0$, $\Delta H > 0$, $\Delta \mathrm{S} > 0$
C) $\Delta G < 0$, $\Delta H < 0$, $\Delta S < 0$
D) $\Delta G > 0$, $\Delta H > 0$, $\Delta S > 0$
E) $\Delta G < 0$, $\Delta H > 0$, $\Delta S < 0$

20. Identify the **TRUE** statement(s) regarding ΔS(reaction):

(i) ΔS may be given in units of J mol^{-1}.
(ii) $\Delta S > 0$ for the melting of any substance.
(iii) The sign of ΔS(rxn) is determined by the sign of ΔH(rxn).
(iv) A reaction is always spontaneous if ΔS(rxn) > 0.
(v) ΔS(rxn) = ΣS(reactants) - ΣS(products).

.

A) i, iii
B) i, v
C) ii, v
D) ii
E) iii, iv

 Continued on next page

21. Calculate the **boiling point** temperature (in °C) of bromine given the following data:

$\Delta H_f°[Br_2(g)]$ = 30.907 kJ mol^{-1}
$S°$ $[Br_2(l)]$ = 152.2 J K^{-1}mol^{-1}
$S°$ $[Br_2(g)]$ = 245.463 J K^{-1}mol^{-1}

A) 126
B) 58
C) 337
D) 17
E) 3

22. The standard elemental form of mercury at 300K is Hg(l). The standard enthalpy of formation for Hg(g) is +60.78 kJ mol^{-1}. The standard entropy of vaporization of mercury is +97.3 J mol^{-1}K^{-1}. Calculate the **pressure** (in bar) of mercury **vapor** (gas) in equilibrium with the mercury liquid, at **300 K**. Hint: write an expression for the equilibrium constant.

.
A) 3.16×10^{-6}
B) 0.904
C) 2.11×10^{5}
D) 11.3
E) 2.97×10^{-3}

23. Zinc is used in the **cathodic protection** of iron because:

.

A) The reaction Fe + $Zn^{2+} \rightarrow Fe^{2+}$ + Zn is spontaneous under standard conditions.
B) Zn will serve as the cathode in the electrochemical process.
C) Fe is a better reducing agent that Zn.
D) Zn is difficult to oxidize.
E) Zn is a better reducing agent than Fe.

24. Given the following data:

$Cu^{2+}(aq) + 2\ e^{-} \rightarrow Cu(s)$ $\quad E^{\circ}_{red} = +0.34$ V
$NO_3^{-}(aq) + 4\ H^{+}(aq) + 3\ e^{-} \rightarrow NO(g) + 2\ H_2O(l)$ $\quad E^{\circ}_{red} = +0.96$ V

Which of the following statements is/are **TRUE** for the balanced spontaneous redox reaction involving the above species? The balanced equation must contain the smallest integers as stoichiometric coefficients.

(i) $E^{\circ}_{cell} = +1.30$ V
(ii) $\Delta G^{\circ} = -359$ kJ mol^{-1}
(iii) $\Delta S^{\circ} > 0$

.

A) i, iii
B) ii
C) ii, iii
D) iii
E) i

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25. The interior and exterior of a nerve cell behave as a concentration cell. If the concentration of K^+ outside the cell is 0.030 M, while the concentration inside is 0.30 M, what is the potential difference across the cell membrane (in volts, V)? Assume normal body temperature, $T = 37$ °C and a one-electron transfer ($n = 1$).

.

A) 0.198
B) 5930
C) 0.0616
D) 0.0267
E) 86.2

26. In the following electrochemical cell,

$$Pt(s) \,|\, H_2(g, 1\ bar) \,|\, H^+ (aq, 1\ M) \,\|\, Cu^{2+} (aq, 1\ M) \,|\, Cu(s),$$

which **one** of the following will cause an **increase** in the cell voltage?

.

A) Decrease the Cu^{2+}(aq) concentration.
B) Increase the size of the Cu electrode.
C) Increase the volume of the Cu^{2+}(aq) solution.
D) Lower the H^+(aq) concentration.
E) Lower the H_2(g) pressure.

27. Cerium is a lanthanide and, like most rare earth metals, its most common oxidation state is +3. In an electrochemical cell, the +4 oxidation state oxidizes chloride ions to chlorine gas. The cell potential is measured to be 0.30 V at 25°C. If the concentrations of all aqueous ions are 2.0 M, what is the **pressure of chlorine gas (in bar)**? Hint: write an expression for the reaction quotient. The standard reduction potentials are given below, with the half-reactions:

$Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$ $\quad E^{o}_{red} = +1.36$ V
$Ce^{4+} \rightarrow Ce^{3+} + e^-$ $\quad E^{o}_{red} = +1.61$ V

.
A) 3.9
B) 0.51
C) 0.021
D) 0.0057
E) 0.082

28. What **potential**, in volts, is developed by the following electrochemical cell?

$Al(s)\ |\ Al^{3+}(0.00100\ M)\ ||\ Cu^{2+}(0.00100\ M)\ |\ Cu(s)$

Data: $Al^{3+}(aq) + 3e^- \rightarrow Al(s)$ $\quad E^{\circ}_{red} = -1.66$ V
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $\quad E^{\circ}_{red} = +0.34$ V

(Hint: balance the cell reaction before you proceed.)

.
A) 1.97
B) 1.94
C) 2.00
D) 2.03
E) 2.06

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29. 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 possible **discrepancy** in the experimentally determined value of K?

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

.

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

30. A student is creating a concentration cell and needs to dilute a 0.020 M solution of Zn^{2+} to 0.0004 M solution. They are given a 1.00 mL pipette (measures only 1.00 mL accurately) and a 100.0 mL volumetric flask (only measure 100.0 mL accurately). **How would they accomplish this accurately**?

.

A) Add 2.00 mL of the 0.02 M solution and fill to 100.00 mL with water.
B) Add 1.00 mL of the 0.02 M solution and fill to 100.0 mL with water.
C) Add 2.00 mL of the 0.02 M solution and fill to 100.00 mL with water, then repeat with the new solution.
D) Add 1.00 mL of the 0.02 M solution and fill to 100.0 mL with water, then repeat with the new solution.
E) none of the above.

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31. A 1.60 g sample of propanoic acid (CH_3CH_2COOH, molecular mass = 74.1 g mol^{-1}, K_a = 1.40 x 10^{-5}) was dissolved in water and made up to a final volume of 100. mL in water. **What is the pH** of this solution?
.
A) 4.85
B) 1.82
C) 3.26
D) 2.32
E) 2.76

32. Heroin, a derivative of morphine, is a powerful analgesic and a powerful narcotic agent. Determine $\boldsymbol{K_b}$ for heroin if the pH of a 1.7 x 10^{-3} M solution is found to be 9.60.
.
A) 9.5 x 10^{-7}
B) 2.3 x 10^{-2}
C) 1.5 x 10^{-7}
D) 3.7 x 10^{-7}
E) 9.3 x 10^{-7}

 Continued on next page

33. From the acids and associated K_a values given below, select the **acid** with the **strongest conjugate base**.

.

A) $CH_3NH_3^+$ 2.5×10^{-11}
B) HCO_3^- 6.3×10^{-11}
C) C_6H_5OH 1.3×10^{-10}
D) CH_3COOH 1.8×10^{-5}
E) H_2CO_3 4.5×10^{-7}

34. For the six substances listed below, identify how many will form **acidic, neutral or basic solutions** (in that order) when each substance is dissolved in water.

LiOH **SO_3** **ClOH** **K_2O** **NaBr** **HNO_2**

.

A)	2	1	3
B)	2	2	2
C)	3	0	3
D)	1	2	3
E)	3	1	2

35. What is the **pOH** of a 100 mL solution of 0.00059 M HNO_3?

.

A) 4.23
B) 10.77
C) 3.23
D) 7.00
E) 9.77

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Extra Space:

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Name: ____________________ Student number: ______________

Some general data are provided on this page.

A Periodic Table with atomic weights is provided on the next page.

R = 8.3145 J K^{-1} mol^{-1} = 0.083145 L bar K^{-1} mol^{-1}

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

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

$h = 6.6256 \times 10^{-34}$ J s

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

density(H_2O, l) = 1.00 g mL^{-1}

Specific heat capacity of H_2O(l) = 4.18 J g^{-1} K^{-1}

F = 96485 C mol^{-1}

1 bar = 100.0 kPa

0°C = 273.15 K

1 J = 1 kg m^2 s^{-2} = 1 kPa L = 1 Pa m^3

1 m = 10^9 nm = 10^{10} Å

1 cm^3 = 1 mL

1 g = 10^3 mg

1 Hz = 1 cycle/s

De Broglie wavelength:
$\lambda = h / mv = h / p$

Hydrogen atom energy levels:
$E_n = -R_H / n^2 = -2.178 \times 10^{-18}$ J / n^2

Nernst Equation (the last two equations are for T = 298.15 K):

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{RT}{zF}\ln Q \quad = E^{\circ}_{\text{cell}} - \frac{0.0257\text{ V}}{z}\ln Q \quad = E^{\circ}_{\text{cell}} - \frac{0.0592\text{ V}}{z}\log_{10} Q$$

Entropy change: $\Delta S = \dfrac{q_{\text{rev}}}{T}$

Gibbs free energy of reaction: $\Delta G = \Delta G^{\circ} + RT\ln Q$

The roots of quadratic equation, $a x^2 + b x + c = 0$, are given by $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

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 and barium 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 salts are *insoluble*, *except* for the alkali metal and ammonium salts

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Name: ____________________ Student number: ______________

PERIODIC TABLE OF THE ELEMENTS

I 1	II 2	3	4	5	6	7	8	9	10	11	12	III 13	IV 14	V 15	VI 16	VII 17	VIII 18
		Transition Metals															
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]												

Atomic weights are based on $^{12}C = 12$ and conform to the 1987 IUPAC report values rounded to 5 significant digits.
Numbers in [ ] indicate the most stable isotope.

* 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 Exam