Name: _____ Student number: _____

Chemistry 1A03 **Test 1** **Sep 29, 2017**

McMaster University **VERSION 1**

Instructors: L. Davis, D. Emslie, S. Greenberg, A.P. Hitchcock

Duration: 90 minutes

This test contains 16 numbered pages printed on both sides. There are **20** multiple-choice questions appearing on pages numbered 3 to 12. Pages 13 and 14 are extra space for rough work. Page 15 includes some useful data and equations, and there is a periodic table on page 16. You may tear off the last page 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 20. There is **no** penalty for incorrect answers.
BE SURE TO ENTER THE CORRECT VERSION 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. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy.

Only **Casio FX991-MS or FX991-MS+** electronic calculators may be used. They must NOT be transferred between students. Use of any aids other than those provided, is not allowed.

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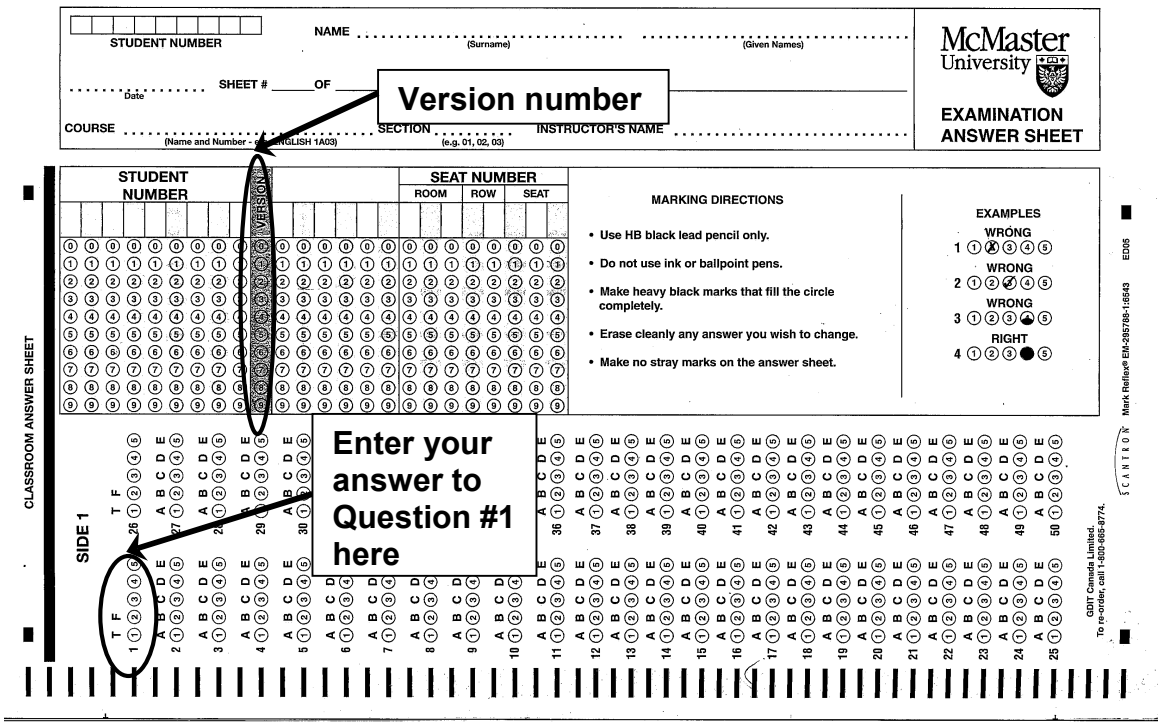
OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: YOUT EXAMINATION 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** in the space provided. If your student number does **NOT** begin with a 4, put "00" before your student number. Then fill in the corresponding bubble numbers underneath.
3. Do NOT put in a leading zero when bubbling in your **exam version number**.
4. 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.
5. Pay particular attention to the marking directions on the form.
6. Begin answering the question using the first set of bubbles, marked "1".



Name: _____ Student number: _____

1. What is the correct chemical formula for **calcium nitrate?**

   A) $CaNO_3$
   B) $Ca(NO_3)_2$
   C) $Ca(NO_2)_2$
   D) Ca_2NO_2
   E) Ca_2NO_3

2. A 1.05 kg piece of pure hematite (Fe_2O_3) is placed in a 150. L container. At 25.0 °C the container is evacuated to 1.05×10^{-5} bar, then filled with 5.05 bar of CO and sealed. The container is heated to 1300 K and the reduction of the hematite to metallic iron goes 100% to completion. The unbalanced reaction is

   $$Fe_2O_3\,(s) + CO\,(g) \rightarrow Fe\,(s) + CO_2\,(g) \qquad (\textit{unbalanced})$$

   After the vessel has cooled to 25.0 °C, what are (i) **mass of Fe(s) in kg**, (ii) **partial pressure of CO_2 (g) in bar**, and (iii) **the total pressure in bar** ?

	m(Fe) (kg)	P(CO_2) (bar)	P-total (bar)
A)	0.734	3.26	5.05
B)	0.721	1.09	2.88
C)	0.721	2.17	5.05
D)	0.852	3.26	4.95
E)	0.734	2.17	5.05

3. A noble gas has a density of 3.425 g L^{-1} at 1.013 bar and 25.0 ^{o}C. **What is the gas?**

   A) He
   B) Ne
   C) Ar
   D) Kr
   E) Xe

4. The density of water, $H_2O(l)$, is 1.0 g/mL. How many **atoms** of hydrogen are present in 2.0 L of pure water?

   A) 1.3×10^{26}
   B) 1.4×10^{21}
   C) 2.3×10^{22}
   D) 1.5×10^{27}
   E) 2.7×10^{26}

5. Which one of the following atoms or ions has the **greatest number of neutrons** ?

A) ^{12}C
B) $^{18}F^{-}$
C) ^{18}Ne
D) $^{18}O^{2-}$
E) $^{15}N^{+}$

6. 100.0 g of propyne (C_3H_4) (g) is burnt in a 30.0 L rigid vessel containing pure O_2 (g) at P = 10.00 bar and an initial temperature of 25.0 °C. At the end of the reaction the temperature of the vessel is 250. °C. At the end of the reaction, what are the **partial pressures (in bar) of CO_2 (g)** and **O_2 (g)** ?

	$P(CO_2)$ (bar)	$P(O_2)$ (bar)
A)	6.20	1.74
B)	27.6	0.00
C)	10.9	2.05
D)	10.9	3.07
E)	5.42	16.4

7. An orbital has the following quantum numbers

   $n = 5, \quad \ell = ?, \quad m_\ell = -2$

   What are the possible value(s) of the ℓ **quantum number** ?

   A) 5, 4, 3, 2 or 1
   B) 5, 4, 3 or 2
   C) 4 only
   D) 4, 3 or 2
   E) 4, 3, 2 or 1

8. For one CO molecule to go from one energy level to another, higher energy level requires the absorption of light with a frequency of 1.16×10^{11} Hz. What is the **energy in kJ mol^{-1}** required for this transition?

   A) 7.96×10^{-23}
   B) 4.63×10^{-2}
   C) 1.03×10^{-12}
   D) 1.39×10^{10}
   E) 1.28×10^{-6}

9. A **doubly charged atomic cation** in an **excited state** has the following electron configuration:

   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ 4s^1$

   The species is:

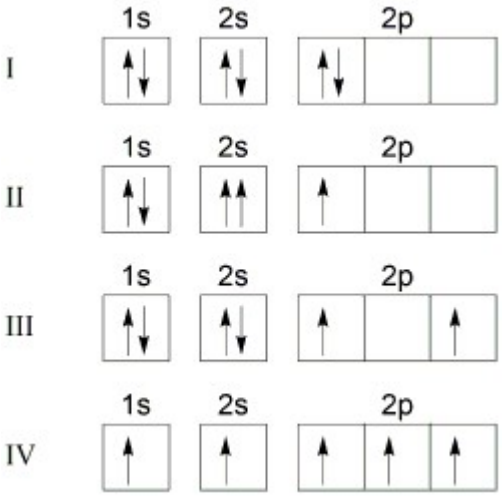
   A) K^{2+}
   B) Ca^{2+}
   C) Sc^{2+}
   D) Ar^{2+}
   E) Cl^{2+}

10. Which of the following atoms in their ground state are **paramagnetic** (i.e. have unpaired electrons)?

    C, O, Mg, Al, P

    A) Only P
    B) Al and P
    C) C, Al and P
    D) C, O, Al and P
    E) C, O, Mg, Al and P

11. Consider the following orbital filling diagrams:



Which orbital filling diagram(s) represent a **valid ground-state configuration** of an atom ?

A) I and II
B) II and III
C) III only
D) I and IV
E) IV only

12. Potassium has a threshold energy of 2.92×10^{-18} J. When light with a wavelength of 38.8 nm is shone on a potassium surface, with what **velocity (in m s^{-1})** will photoelectrons be ejected?

A) 2.20×10^{6}
B) 5.13×10^{8}
C) 2.43×10^{12}
D) 1.56×10^{9}
E) Photoelectrons will not be ejected.

13. An electron in a hydrogen atom undergoes a transition from n = 2 to n = 3. Which of the following two statements are **FALSE**?

(i) A photon is emitted in the transition.
(ii) The atom started out in an excited state.
(iii) Light with a wavelength of 656 nm has the same energy as this transition.
(iv) The frequency of light for the transition from n = 2 to n = 3 is higher than the frequency of light for the transition from n = 1 to n = 2.

A) i and ii
B) iii and iv
C) i and iii
D) ii and iii
E) i and iv

14. Select the two **most electronegative** atoms from the following list:

Be, Br, Cl, Na, O

A) Na and Be
B) Na and Cl
C) O and Br
D) O and Cl
E) Br and Cl

15. Arrange the following species from **largest to smallest radius**:

S^{2-}, Al^{3+}, Cl, Si, Mg^{2+}, Mg

A) S^{2-} Mg Si Cl Mg^{2+} Al^{3+}
B) Mg Mg^{2+} Al^{3+} Si S^{2-} Cl
C) S^{2-} Mg Mg^{2+} Si Cl Al^{3+}
D) S^{2-} Mg^{2+} Al^{3+} Mg Si Cl
E) Mg Si Cl S^{2-} Mg^{2+} Al^{3+}

16. Which one of the following statements is **FALSE** ?

A) The magnitude of the electron affinity of P is larger than that of Si
B) The atomic radius of Li is smaller than that of Na
C) The first ionization energy of Mg is larger than that of Al
D) The metallic character of Rb is greater than that of K
E) The value of Z_{eff} for the outermost valence electrons is larger for Xe than for Rb

17. What is the **magnitude of the energy <u>difference</u> (in kJ)** required to ionize 2.00 g of Cs versus 2.00 g of Rb ? The ionization energies of Cs and Rb are 375.7 kJ mol^{-1} and 403.0 kJ mol^{-1}, respectively.

    A) 27.3
    B) 3.78
    C) 14.2
    D) 94.8
    E) 54.6

18. The ground state of two elements, A and B, have the following electron configurations:

    A = $[He]2s^2 2p^5$ B = $[Ne]3s^2 3p^1$

    Which one of the following statements regarding these two elements is **FALSE** ?

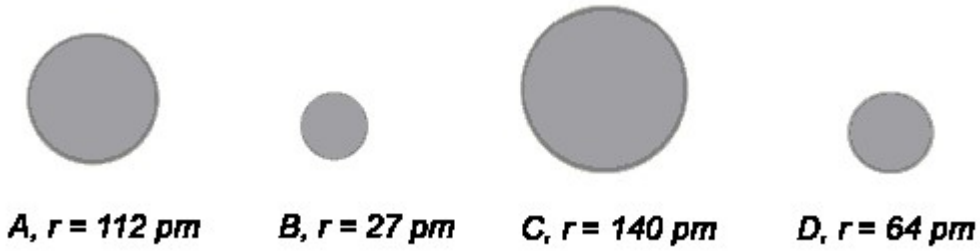
    A) Element A has more metallic character than element B
    B) Element A has a smaller atomic radius than element B
    C) Element A has a higher magnitude of electron affinity than element B
    D) Element A has a higher first ionization energy than element B
    E) In atomic form, elements A and B are both paramagnetic (i.e. have unpaired electrons)

19. When the following atoms are ranked from **highest to lowest first ionization energy**, which atom falls in the **middle** of the series**:**

B, Be, C, F, Na

A) Be
B) Na
C) C
D) F
E) B

20. The following four spheres represent Be, Be^{2+}, O and O^{2-} (not necessarily in that order).



Which pair **of reactions** is most consistent with the **relative sizes of these species** ?

A) $A \rightarrow B + 2e^-$ and $D + 2e^- \rightarrow C$
B) $A \rightarrow C + 2e^-$ and $D + 2e^- \rightarrow B$
C) $A \rightarrow D + 2e^-$ and $C + 2e^- \rightarrow B$
D) $A + 2e^- \rightarrow C$ and $D \rightarrow B + 2e^-$
E) $A + 2e^- \rightarrow B$ and $C \rightarrow D + 2e^-$

Extra space for rough work

Name: _____ Student number: _____

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

STP = 273.15 K, 1 atm
$N_A = 6.022 \times 10^{23}$ mol^{-1}
$h = 6.6256 \times 10^{-34}$ Js
density(H_2O, l) = 1.00g/mL
F = 96485 C/mol
$c = 2.9979 \times 10^{8}$ m/s
$m_e = 9.109 \times 10^{-31}$ kg
$\Delta H^{o}_{vap}[H_2O] = 44.0$ kJ mol^{-1}
Specific heat of water = 4.184 J / g·°C
$R = 8.3145$ J K^{-1} mol^{-1} = 0.08206 L atm K^{-1} mol^{-1} = 0.083145 L bar K^{-1} mol^{-1}

1 bar = 100.00 kPa = 750.06 mm Hg = 0.98692 atm
1 J = 1 kg m^2 s^{-2} = 1 kPa L = 1 Pa m^3
1 cm^3 = 1 mL
1 Hz = 1 cycle/s
0°C = 273.15 K
1 m = 10^6 µm = 10^9 nm = 10^{10} Å
1 g = 10^3 mg

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

Hydrogen atom energy levels:
$E_n = -R_H / n^2 = -2.179 \times 10^{-18}$ J / n^2
$KE = ½mu^2$

Nernst Equation:

$$E = E° - \frac{RT}{zF}\ln Q \quad = E° - \frac{0.0257\ \text{V}}{z}\ln Q \quad = E° - \frac{0.0592\ \text{V}}{z}\log_{10} Q$$

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

Solubility Guidelines for Common Ionic Solids

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.

1. Salts of group 1 cations and the NH_4^+ cation are soluble . Except LiF and Li_2CO_3 which are insoluble.
2. Nitrates, acetates, bicarbonates, and perchlorates are soluble.
3. Salts of silver, lead and mercury (I) are insoluble. Except AgF which is soluble.
4. Fluorides, chlorides, bromides, and iodides are soluble. Except Group 2 fluorides which are insoluble
5. Carbonates, phosphates, chromates, sulfides, oxides, and hydroxides are insoluble. Except Group 2 sulfides and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} which are soluble.).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

Name: ____________________ Student number: ______________

PERIODIC TABLE OF THE ELEMENTS

ALDRICH®

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
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					Transition Metals						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