Name: _____ Student number: _____

Chemistry 1A03	**Test 1**	**Sep 30, 2016**
McMaster University	**VERSION 1**	**17:30 –19:00**

Instructors: L. Chen, L. Davis, D. Emslie, A. 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 2 marks - the total marks available are 40. 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 FX 991 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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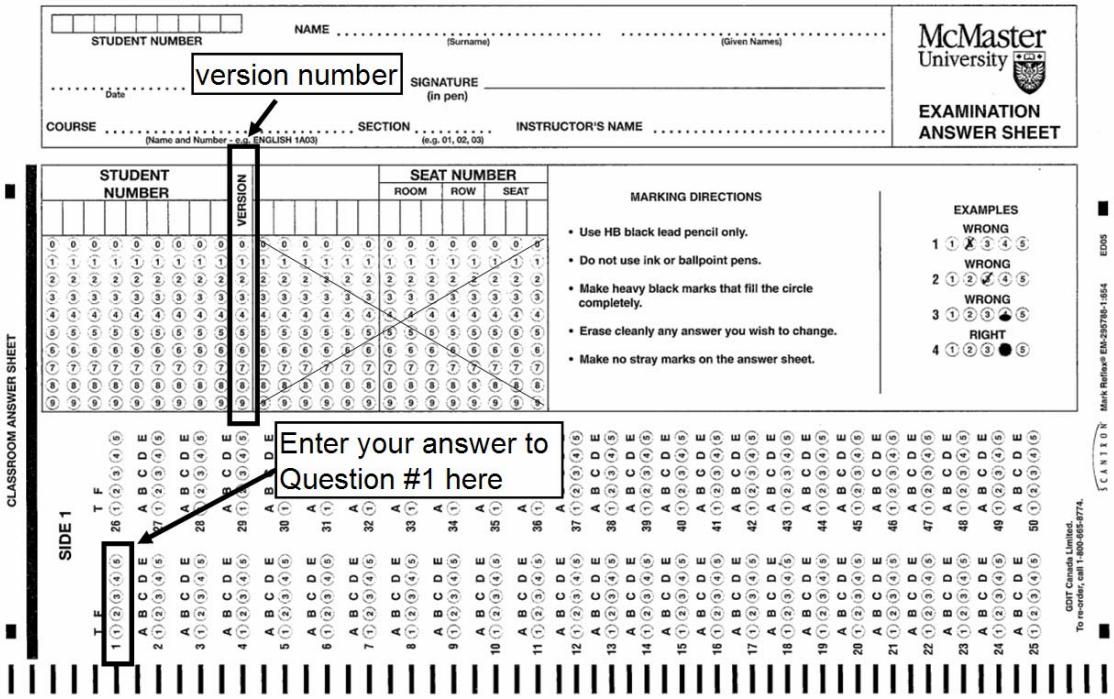
OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: YOUR 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. **ONLY USE THE RED SIDE OF THE OMR FORM.**
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".



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1. What is the **atomic mass** of carbon?

   A) 58.93
   B) 6
   C) 16
   D) 6.94
   E) 12.01

2. The nucleus of which **one** species contains the greatest number of **protons**?

   A) F^-
   B) P^-
   C) Cl^-
   D) S^{2+}
   E) Si^-

3. A sample of titanium dioxide (TiO_2) with a mass of 2.024 g is heated in excess H_2 gas to produce water vapour and 1.889 g of *another* titanium oxide. What is the **empirical formula** of the titanium oxide produced? The unbalanced equation for this reaction is:

$$TiO_2\ (s) + H_2\ (g) \rightarrow Ti_xO_y\ (s) + H_2O\ (g) \quad \textit{(unbalanced)}$$

A) TiO_3
B) Ti_2O
C) Ti_3O_5
D) TiO
E) Ti_2O_3

4. Identify the **FALSE** statement among the following statements.

A) A group and a period will intersect at a right angle.
B) If pieces of two different metals have equal volume, the metal with the highest density will have the lowest mass.
C) The atomic number of an element is always smaller than the average atomic mass of the natural abundance of that element.
D) The oxidation number of P in PO_4^{3-} is +5.
E) Concentration is an intensive property.

5. How many **grams** of calcium oxide, CaO, can be produced from 4.20 g of calcium metal and 1.60 g of oxygen gas?

   A) 5.26
   B) 2.80
   C) 5.61
   D) 6.80
   E) 2.94

6. What is the **oxidation state** of boron in B_2O_3 ?

   A) −2
   B) −2
   C) +1
   D) −3
   E) +3

7. Which **one** of the following is **NOT** an allowable set of quantum numbers?

A)	n = 3	$\ell = 2$	$m_\ell = -2$	$m_s = 1/2$
B)	n = 1	$\ell = 0$	$m_\ell = 0$	$m_s = -1/2$
C)	n = 2	$\ell = 0$	$m_\ell = 0$	$m_s = 1/2$
D)	n = 2	$\ell = 1$	$m_\ell = -1$	$m_s = 1/2$
E)	n = 3	$\ell = 3$	$m_\ell = -1$	$m_s = 1/2$

8. Which of the following statements regarding the transition of an electron from **n = 5 to n = 3** in a hydrogen atom are **FALSE**?

i) The wavelength of light emitted from this transition is 1282 nm.
ii) The wavelength of light emitted for this transition is shorter than the wavelength emitted for the transition from n = 4 to n = 2.
iii) The electron has relaxed to the ground state.
iv) The atom has not been ionized during this transition.
v) The value of ΔE for this transition is negative.

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

9. The following electron configuration would represent a singly charged **anion** of which **one** of the following elements?

$$1s^2 2s^2 2p^6 3s^2 3p^6$$

A) Argon
B) Sodium
C) Potassium
D) Calcium
E) Chlorine

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

A) An electronic transition from n = 1 to n = 2 is higher energy than a transition from n = 2 to n = 3.
B) The wavelength of blue light is shorter than that of green light.
C) Atomic absorption spectra can be used to identify the presence of elements in a given sample.
D) Absorption and emission processes involving transitions between the same pair of energy levels do not have the same energy.
E) Atomic absorption spectra can be used to quantify the amount of an element in a given sample.

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11. How many **electrons** in an atom can be described by the following set of quantum numbers?

$n = 3$ $\ell = 2$ $m_\ell = 1$

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

12. The photoelectric effect is observed for a certain metal that has a threshold energy of 4.12×10^{-19} J. What is the **wavelength of the incident light in nanometers**, if the electrons ejected from the surface of this metal have a velocity of 7.26×10^{5} m s^{-1} ?

A) 423
B) 375
C) 402
D) 211
E) 305

13. Which of the following statements regarding the photoelectric effect are **FALSE**?

(i) The number of photoelectrons generated depends on the intensity of the incident light.
(ii) Photoelectrons are generated when the frequency of the incident light is lower than the threshold frequency.
(iii) Photoelectrons can be generated when light strikes a metal surface to which a voltage is applied.
(iv) The kinetic energy of the emitted electrons depends on the intensity of the incident light.
(v) The threshold energy of the metal must be lower than the energy of the incident light to eject an electron.

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

14. The **effective nuclear charge (Z_{eff})** felt by the outermost electrons is the **strongest** for which of the following elements?

A) F
B) N
C) Be
D) B
E) O

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

A) The first ionization energy of N is greater than that of O.
B) The first ionization energy of B is smaller than that of Be.
C) The effective nuclear charge, Z_{eff}, felt by the valence electrons of Al is greater than that of S.
D) The electron affinity of F is more negative than that of O. (note: the electron affinity of O is -141 $kJ.mol^{-1}$).
E) When dissolved in water, MgO is basic.

16. Which **one** of the following species is in the *middle* position when the following five atoms and ions are ranked according to increasing **size**?

$N, P, Cs, Mg^{2+}, Cl^{-}$

A) Mg^{2+}
B) Cl^{-}
C) N
D) P
E) Cs

17. How **many** of the following species will **react** when placed in a solution of HNO_3 (aq)?

Na_2O, CaO, Al_2O_3, SiO_2, Cl_2O_7

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

18. Which **one** of the following reactions represents the **third ionization energy** of vanadium?

A) $V^{2-}(g) + e^- \rightarrow V^{3-}(g)$
B) $V^{3+}(g) \rightarrow V^{4+}(g) + e^-$
C) $V^{3+}(g) + e^- \rightarrow V^{2+}(g)$
D) $V(g) \rightarrow V^{3+}(g) + 3e^-$
E) $V^{2+}(g) \rightarrow V^{3+}(g) + e^-$

19. Which **one** of the following relationships regarding ionic and/or atomic **size** is **TRUE**?

A) $Na < Na^{+}$
B) $Cl < Cl^{-}$
C) $Al < Al^{3+}$
D) $S^{2-} < O^{2-}$
E) $Ne^{2+} < Ne^{3+}$

20. Which **one** of the following species is **diamagnetic**?

A) Cr^{2+}
B) Sr^{+}
C) I^{-}
D) Co^{3+}
E) Br

Extra space for rough work

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

Aqueous Solubiity: 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.

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END OF EXAM