Name: ____________________ Student number: ______________

Chemistry 1A03	**Test 2**	**Nov 11, 2016**
McMaster University	**VERSION 1**	**17:30 –19:30**

Instructors: L. Chen, L. Davis, D. Emslie, A. Hitchcock

Duration: 120 minutes

This test contains 10 sheets of paper, printed on both sides, for a total of 20 numbered pages. There are **28** multiple-choice questions appearing on pages numbered 3 to 16. Pages 17 and 18 are extra space for rough work. Page 19 includes some useful data and equations, and there is a periodic table on page 20. 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 56. 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.

<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. They must NOT be transferred between students. Use of any aids other than those provided, is not allowed.

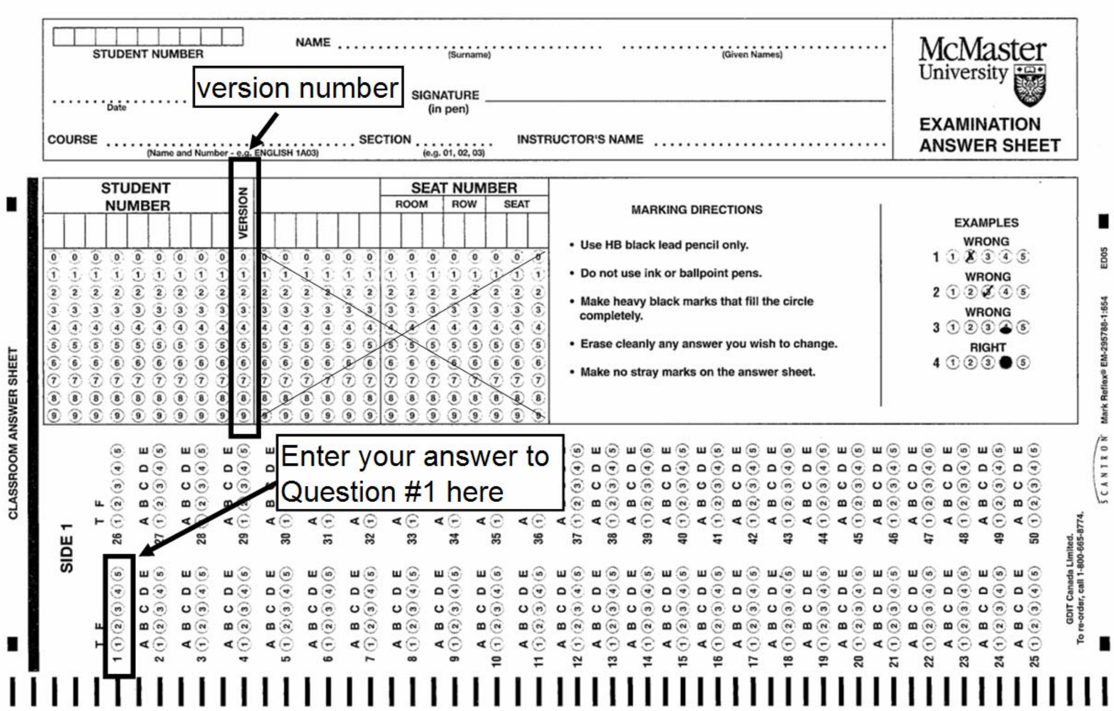
Name: ____________________ Student number: ______________

OMR EXAMINATION – STUDENT INSTRUCTIONS

NOTE: IT IS YOUR RESPONSIBILITY TO ENSURE THAT THE ANSWER SHEET IS PROPERLY COMPLETED: 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".



1. Carbon has two stable isotopes with natural abundances of 98.93% (^{12}C) and 1.07% (^{13}C). **How many atoms** of ^{13}C are there in a 2.05 g sample of **carbon dioxide**?

   A) 3.00×10^{20}
   B) 1.45×10^{21}
   C) 9.67×10^{20}
   D) 6.44×10^{21}
   E) 1.10×10^{21}

2. What **volume** (in mL) of $^{37}Cl_2$ is required to produce 1.00 g of $K^{37}Cl$ based on the following *unbalanced redox reaction* at 25°C and 2.00 atm.

   $$Cl_2\,(g) + KOH\,(aq) \rightarrow KCl\,(aq) + KClO_3\,(aq) + H_2O\,(l) \qquad \text{(unbalanced)}$$

   A) 88.3
   B) 96.4
   C) 98.4
   D) 154
   E) 75.4

 Continued on next page

3. Aluminium reacts **completely** with a platinum chloride compound according to the *unbalanced* reaction:

$$Al(s) + PtCl_x(aq) \rightarrow AlCl_3(aq) + Pt(s) \quad \text{(unbalanced)}$$

When a 1.025 g sample of platinum chloride, $PtCl_x$, is dissolved in water and reacts with an excess of aluminium, 0.594 g of platinum is produced. What is the **empirical formula** of the platinum chloride?

A) $PtCl_2$
B) Pt_2Cl_5
C) $PtCl_3$
D) $PtCl_6$
E) $PtCl_4$

4. Which **one** of the following elements is the **least electronegative** ?

A) Magnesium
B) Rubidium
C) Gallium
D) Arsenic
E) Fluorine

5. Which **one** of the following statements regarding the transition from **n = 1 to n = 2** in a hydrogen atom is **FALSE** ?

   A) The wavelength of light absorbed in this transition is 145 nm.
   B) The wavelength of light absorbed in this transition is shorter than the wavelength absorbed for the transition from n = 2 to n = 3.
   C) The electron was initially in the ground state.
   D) The atom has not been ionized during this transition.
   E) The wavelength of light absorbed in this transition is not in the visible region of the electromagnetic spectrum.

6. In a photoelectric effect experiment, a certain metal is struck with light of 765 nm and electrons are ejected with a velocity of 4.56×10^5 m s^{-1}. What is the **threshold energy** of this metal, in **Joules** ?

   A) 1.65×10^{-19}
   B) 1.15×10^{-19}
   C) 2.03×10^{-19}
   D) 1.72×10^{-19}
   E) 2.84×10^{-19}

7. Which **one** of the following elements has the **greatest** magnitude of **electron affinity** ?

   A) Mg
   B) Cl
   C) S
   D) Na
   E) I

8. Which **one** of the following has the **smallest first ionization energy** ?

   A) Mg
   B) Al
   C) Si
   D) P
   E) S

 Continued on next page

9. The electron affinity (EA) of an iodine atom (I) can be determined by using a laser light to just ionize the iodide anion (I^-) in the gas phase. Calculate the **wavelength in nanometers** (nm) of laser light that corresponds to the electron affinity of iodine.
Data: EA(I) = −295.2 kJ mol^{-1}.

A) 672.9
B) 589.3
C) 434.1
D) 405.2
E) 334.8

10. What is the **electron pair geometry** for the sulfite anion, SO_3^{2-}?

A) Trigonal planar
B) Trigonal pyramidal
C) Tetrahedral
D) Trigonal bypyramidal
E) Octahedral

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

A) The bond order in O_2 is higher than that in Cl_2.
B) The bond between the carbon atoms in ethyne (C_2H_2) is stronger than that in ethene (C_2H_4).
C) The electrons in the bonds in O_2 are less equally shared than those in the bonds in CH_4.
D) CO binds to hemoglobin more strongly than O_2.
E) CO has a larger dipole moment than O_2.

12. A series of singly charged anions have the general formula $[PF_nCl_{(6-n)}]^-$ where n = 0,1,2,3,4,5,6. **How many unique, polar** molecules exist for this series ?

A) 2
B) 4
C) 6
D) 11
E) 16

13. Considering the Lewis structure of selenite (SeO_3^{2-}), which **one** of the following statements is **TRUE** ?

A) All atoms in the molecule obey the octet rule.
B) The average formal charge on the oxygen atoms is −1/3.
C) There are two resonance structures.
D) There are 7 lone pairs of electrons in the molecule.
E) The average Se-O bond order is 4/3.

14. Which **one** of the following molecules or anions contains a **bond angle** that is **less than 109.5°** ?

A) KrF_2
B) CO_3^{2-}
C) CS_2
D) NO_2^-
E) H_2S

 Continued on next page

15. Which **one** of the following molecules or ions has **exactly eight valence electrons** around the central atom ?

A) $GaCl_3$
B) PH_3
C) ICl_2^-
D) SO_3
E) AsO_4^{3-}

16. Aqueous solutions of $Pb(NO_3)_2$ (10 ml, 0.020 M) and NaCl (10 ml, 0.020 M) are mixed together. **Determine Q_{sp}** immediately after mixing and **indicate if a precipitate will form.**
Data: K_{sp} ($PbCl_2$) = 1.6×10^{-5}

A) $Q_{sp} = 1 \times 10^{-6}$ & no precipitate will form
B) $Q_{sp} = 1 \times 10^{-4}$ & a precipitate will form
C) $Q_{sp} = 4 \times 10^{-6}$ & a precipitate will form
D) $Q_{sp} = 4 \times 10^{-6}$ & no precipitate will form
E) $Q_{sp} = 1 \times 10^{-4}$ & no precipitate will form

17. Which **one** of the following pairs of reagents, each as 0.10 M solutions, would produce **NO observable reaction** when mixed together ?

A) $Zn(CH_3COO)_2$ (aq) and $AgClO_4$ (aq)
B) $Pb(NO_3)_2$ (aq) and $CuCl_2$ (aq)
C) Na_2CO_3 (aq) and HCl (aq)
D) K (s) and $Au(NO_3)_3$ (aq)
E) Zn (s) and HCl (aq)

18. What is the **concentration (M)** of silver in a saturated solution of silver arsenate (Ag_3AsO_4) ?
Data: $K_{sp} = 1.0 \times 10^{-22}$

A) 1.7×10^{-6}
B) 4.2×10^{-6}
C) 3.4×10^{-7}
D) 9.1×10^{-5}
E) 1.4×10^{-4}

19. Consider the following gas phase equilibrium:

$$SF_4\,(g) + F_2\,(g) \rightleftharpoons SF_6\,(g)$$

Initially, the partial pressures of each of SF_4 and F_2 are 1.00 atm in a 1.00 L vessel at 400. K. The reaction then takes place, giving a total pressure in the vessel of 1.50 atm. (note: the reaction does not go to completion and there are no side reactions). What **net change in the number of polar molecules** occurs from before, to after the reaction ?

A) 9.18×10^{21}
B) 3.22×10^{21}
C) 6.74×10^{21}
D) 1.18×10^{22}
E) 2.27×10^{20}

20. What is the **pH** of a 0.020 M solution of monochloroacetic acid ($CH_2ClCOOH$) ?
Data: K_a ($CH_2ClCOOH$) = 1.35×10^{-3}

A) 2.08
B) 1.49
C) 2.34
D) 3.56
E) 4.21

21. The following reaction is carried out in a closed vessel.

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g) \quad + \text{ heat}$$

Which of the following conditions will **increase** the amount of NO at equilibrium ?

i. The reaction temperature is increased.
ii. The volume of the reaction container is reduced.
iii. He (g) is added to the reaction.
iv. The reaction temperature is lowered.
v. The partial pressure of O_2 is increased.

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

22. What is the **pH** of a 0.105 M aqueous solution of KOH?

A) 0.895
B) 13.021
C) 12.031
D) 11.439
E) 1.263

23. A sealed container with a total volume of 2.0 L at 298 K is exactly half-filled with an ocean water standard that has a pH of 7.00 and contains no dissolved CO_2. The remaining volume is filled with air at a total pressure of 1.03 bar that is 0.040 mol % CO_2 (i.e. 0.040 % partial pressure of CO_2). The container is left overnight to equilibrate. In the morning, the pH of the ocean water is measured and found to be 5.98. Assuming that acidification of the ocean water only took place via the reaction below, what **percentage of CO_2** from the air sample has reacted to form HCO_3^- (aq) ?

$$CO_2\,(aq) + 2\,H_2O\,(l) \rightleftharpoons H_3O^+\,(aq) + HCO_3^-\,(aq) \qquad K_a\,(H_2CO_3) = 4.4 \times 10^{-7}$$

A) 21
B) 31
C) 53
D) 72
E) 15

24. What is the **pH** of a solution prepared by dissolving 2.14 g NH_4Cl (MM = 53.491 g/mol) in 2.00 L water ? Assume that the addition of NH_4Cl does not affect the volume of the solution.
Data: $K_b\,(NH_3) = 1.8 \times 10^{-5}$

A) 7.47
B) 8.01
C) 3.41
D) 5.48
E) 6.02

25. Which of the following statements are **FALSE** ?

i) The Arrhenius definition applies only to protic acids and metal hydroxides in water.
ii) The strength of a base can also be described by the stability of its conjugate acid.
iii) For binary acids, the anion/conjugate base stability decreases down a group.
iv) HF is a stronger acid than $HClO_4$.
v) HCl is defined as an acid in both the Lewis and Arrhenius descriptions of acid/base theory.

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

26. Which of the following relationships are **FALSE** with respect to acid strength ?

i) $HI < HCl$
ii) $HClO_3 < HClO_4$
iii) $H_2O < NH_3$
iv) $HF < HBr$
v) $CBr_3COOH < CCl_3COOH$

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

27. A 0.153 M solution of an acid, HA, has a percent ionization of 0.912 %. What is the value of the **acid dissociation constant**, $\mathbf{K_a}$, for this acid ?

A) 1.28×10^{-5}
B) 1.87×10^{-5}
C) 1.94×10^{-7}
D) 1.59×10^{-6}
E) 1.31×10^{-4}

28. In experiment 2, The Cycles of Copper, a student records an initial mass of copper of 0.2512 g. The student has to leave lab early so the TA tells them to record the mass of the black precipitate rather than completing the remaining reactions that would return the copper to its elemental form. The student records the mass of the dried black precipitate as 0.2147 g. What **percent recovery** of copper did this student achieve ?

A) 88.12
B) 83.47
C) 72.31
D) 68.28
E) 66.21

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Name: ____________________   Student number: ______________

Extra space for rough work

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Name: ____________________ Student number: ______________

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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.

STP = 273.15 K, 1 atm

$F = 96485$ C/mol

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

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

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

$m_e = 9.109 \times 10^{-31}$ kg

density(H_2O, l) = 1.00g/mL

$\Delta H^{o}_{vap}[H_2O] = 44.0$ 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

0°C = 273.15 K

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

1 m = 10^6 μm = 10^9 nm = 10^{10} Å

1 cm^3 = 1 mL

1 g = 10^3 mg

1 Hz = 1 cycle/s

De Broglie wavelength:

$\lambda = h / mu = h / p$

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

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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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
		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