Name: _____ **Student number: _____**

Chemistry 1E03 **Test 1** **Oct. 18, 2013**

McMaster University ***VERSION 1***

Instructors: Drs. R.S. Dumont & A.P. Hitchcock

Duration: 100 minutes

This test contains 17 numbered pages printed on both sides. There are **25** multiple-choice questions appearing on pages numbered 3 to 13. Pages 14 and 15 provide extra space for rough work. Page 16 includes some useful data and equations, and there is a periodic table on page 17. 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 2 marks; the total marks available are 50. 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. 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.

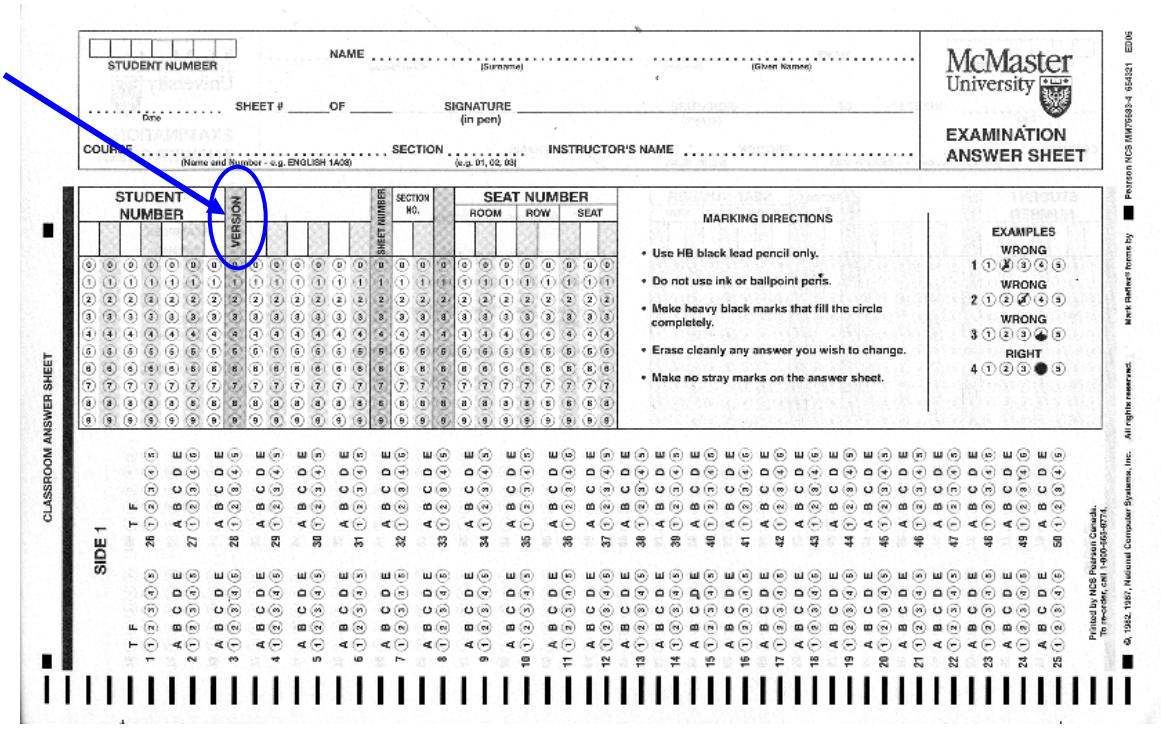
Name: _____ Student number: _____

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”.



Name: _____ Student number: _____

1. The amount of SO_2 present in a sample of air can be determined by titration with a solution of $KMnO_4$. **How many moles** of SO_2 are present in a sample of air, if the sample of SO_2 is consumed by 5.87 mL of 0.00800 M $KMnO_4$ solution?

$$5\ SO_2 + 2\ MnO_4^- + 2\ H_2O \longrightarrow 5\ SO_4^{2-} + 2\ Mn^{2+} + 4\ H^+$$

.

A) 1.88×10^{-5}
B) 9.39×10^{-6}
C) 5.70×10^{-5}
D) 9.79×10^{-4}
E) 1.17×10^{-4}

2. The cation $^{33}S^+$ contains

.

A) 17 neutrons, 16 protons, 17 electrons
B) 33 neutrons, 17 protons, 16 electrons
C) 16 neutrons, 16 protons, 15 electrons
D) 17 neutrons, 17 protons, 16 electrons
E) 17 neutrons, 16 protons, 15 electrons

3. A certain gas weighs 0.988 g and occupies a volume of 1.00 L at a pressure of 0.928 atm and a temperature of 46.8°C. Which gas could this be?

.

A) CH_4
B) CF_4
C) CO
D) CO_2
E) Cl_2

4. What is the empirical formula for iron(III) sulfide?

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A) Fe_3S_2
B) FeS
C) Fe_2S
D) Fe_2S_3
E) FeS_3

5. What **mass** (in g) of **CaO(s)** is produced when 6.80 g of calcium metal reacts with 2.00 L of oxygen at 298 K and 1.00 atm pressure?

.

A) 6.89
B) 9.17
C) 10.1
D) 9.87
E) 8.14

6. Consider the following unbalanced redox reaction in **acidic solution**. What is the **coefficient** of H^+, and the **number of electrons** transferred, when the reaction is **balanced** using the **smallest whole-number coefficients**?

$$H_2S + MnO_4^- \longrightarrow Mn^{2+} + SO_4^{2-}$$

.

A) 6, 80
B) 14, 40
C) 12, 80
D) 4, 80
E) 8, 40

7. You are given two solutions, A and B. One contains **KCl(aq)**, while the other contains **$NaNO_3$(aq)**. Which **one** of the following test solutions can be used to distinguish which of solutions A and B is KCl(aq)?

.

A) $H_2SO_4(aq)$
B) $KMnO_4(aq)$
C) $Ba(OH)_2(aq)$
D) $CuClO_4(aq)$
E) $AgCH_3COO(aq)$

8. Which **one** reaction is **not** an **acid-base** reaction?

.

A) $NaH_2PO_4(aq) + Li_2CO_3(aq) \longrightarrow Na^+(aq) + HPO_4^{2-}(aq) + 2\ Li^+(aq) + HCO_3^-(aq)$
B) $BaO(s) + 2\ HCl(aq) \longrightarrow BaCl_2(aq) + H_2O(l)$
C) $KHCO_3(aq) + KOH(aq) \longrightarrow K_2CO_3(aq) + H_2O(l)$
D) $3\ Cu(s) + 2\ MnO_4^-(aq) + 4\ H_2O(l) \longrightarrow 3\ Cu^{2+}(aq) + 2\ MnO_2(s) + 8\ OH^-(aq)$
E) $CH_3COOH(aq) + H_2O(l) \longrightarrow CH_3COO^-(aq) + H_3O^+(aq)$

9. Identify the **oxidizing agent** in the following reaction:

$$HS^-(aq) + 4\ ClO^-(aq) + OH^-(aq) \longrightarrow SO_4^{2-}(aq) + 4\ Cl^-(aq) + H_2O(l)$$

.

A) ClO^-
B) OH^-
C) Cl^-
D) HS^-
E) SO_4^{2-}

10. Which of the following reactions is **not** an oxidation-reduction?

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A) $Na(s) + H_2O(l) \longrightarrow Na^+(aq) + OH^-(aq)$

B) $CH_4(g) + 2\ O_2(g) \longrightarrow CO_2(g) + 2\ H_2O(l)$

C) $Cl_2(aq) + 2\ Br^-(aq) \longrightarrow 2\ Cl^-(aq) + Br_2(aq)$

D) $NH_4NO_3(s) \longrightarrow N_2(g) + 2\ H_2O(l) + ½\ O_2(g)$

E) $NH_3(aq) + HF(aq) \longrightarrow NH_4^+(aq) + F^-(aq)$

11. A reaction is carried out in aqueous solution, in a constant pressure ("coffee-cup") calorimeter. The **temperature** of the solution is observed to **decrease**. Which **one** of the following statements **must** be **TRUE**?

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A) The reaction is a neutralization reaction.

B) The reaction is exothermic.

C) The reaction is endothermic.

D) Work is done on the surroundings, as the reaction proceeds.

E) The reaction is a formation reaction.

12. Identify the **TRUE** statement(s):

(i) If a reaction produces a net increase in moles of gas, the work done on the system (the reaction mixture) is negative.

(ii) The melting of ice is endothermic.

(iii) The standard enthalpy of formation of $Cl_2(g)$ is zero.

.

A) i, ii, iii

B) i, ii

C) i

D) ii

E) ii, iii

13. How much **heat flow**, in kJ, is required to convert 63.0 g of ice (solid water) at −15.0°C to liquid water at 10.0°C? The enthalpy of fusion (melting) of ice at 0°C is 6.01 kJ mol^{-1}. The specific heat capacities of ice and liquid water are on the data page.

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A) 5.72
B) 175
C) 25.6
D) 33.0
E) 15.1

14. Calculate the **standard enthalpy of formation**, ΔH_f^o, in kJ mol^{-1}, for **SO_2(g)** from the following data:

$S(s) + 3/2\ O_2(g) \longrightarrow SO_3(g)$ $\quad \Delta H^o = -395.2$ kJ mol^{-1}
$2\ SO_2(g) + O_2(g) \longrightarrow 2\ SO_3(g)$ $\quad \Delta H^o = -198.2$ kJ mol^{-1}

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A) −10.6
B) −192.0
C) −89.1
D) −296.1
E) 192.0

15. $PCl_5(s)$ can be prepared by the reaction $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$. Calculate the **enthalpy change** (in **kJ**) that accompanies the production of **100.0 g** of $PCl_5(s)$ by the above reaction, given the following data:

$P_4(s) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(l)$ $\quad \Delta H^o = -1280$ kJ per mole of $P_4(s)$
$P_4(s) + 10\ Cl_2(g) \rightarrow 4\ PCl_5(s)$ $\quad \Delta H^o = -1774$ kJ per mole of $P_4(s)$

.

A) +134
B) −134
C) −78.1
D) +59.3
E) −59.3

16. A detector receives a signal consisting of green light, with a wavelength of 540 nm. The energy of the signal is 2.50×10^{-14} J. How many photons reach the detector?

.

A) 1.48×10^{7}
B) 6.79×10^{4}
C) 2.10×10^{-5}
D) 1.48×10^{4}
E) 3.25×10^{7}

17. Which of the following statements regarding quantum mechanics are **FALSE**?

(i) The energy of a photon is proportional to its frequency.
(ii) In a hydrogen atom, the electron is at a fixed distance from the nucleus.
(iii) As the velocity of a given particle gets larger, its wavelength gets shorter.
(iv) The size of an atomic orbital is mainly determined by the magnetic quantum number.
(v) For a given shell of a many-electron atom, d orbitals have higher energy than s orbitals.

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

18. Which **one** of the following choices lists the species in order of increasing size?

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A) $I^- < I < Br$
B) $F^- < F < Cl$
C) $F^- < Cl^- < Cl$
D) $Cl^+ < Cl^- < Cl$
E) $F < F^- < Cl^-$

19. The photoelectric effect is observed for a certain metal using light of wavelength 490 nm or smaller. What is the **minimum energy**, in J, that is required to eject **one** electron from the surface of this metal?

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A) 8.93×10^{-19}
B) 5.14×10^{-18}
C) 4.06×10^{-19}
D) 6.53×10^{-7}
E) 1.17×10^{3}

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

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A) Nitrogen atoms in their ground state are paramagnetic.
B) $[He]2s^2$ is the electron configuration of the ground state of a Be atom.
C) Calcium atoms in their ground state are paramagnetic.
D) $[He]2s^2\ 2p^5$ is the electron configuration of the ground state of a F atom
E) $[Ar]4s^1 3d^1$ is the electron configuration of an excited state of a Ca atom.

21. Identify the **TRUE** statement(s):

(i) Be has a larger atomic radius than B.
(ii) Overall, electronegativity decreases from left to right across a period.
(iii) F^- has a smaller ionic radius than Na^+.
(iv) Rb has a lower first ionization energy than Na.
(v) All period 2 elements form acidic oxides.

.

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

22. C is the central atom in the thiocyanate anion, SCN^-. The **best** Lewis structure has the following **S, C and N** formal charges, respectively:

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A) 0, +1, −2
B) −1, 0, 0
C) −2, +1, 0
D) −1, +1, −1
E) 0, 0, −1

23. How many **resonance structures** are required to portray the bonding in HSO_3^- ? (Sulfur is the central atom, is bonded only to oxygen atoms and has zero formal charge).

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A) 6
B) 0
C) 1
D) 3
E) 2

24. Based on Lewis structures with minimized formal charges, which of the following species would be expected to have the **longest** nitrogen-oxygen bond?

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A) NO_3^-
B) NO_2^+
C) NO_2^-
D) NO
E) NO^+

25. Choose the **one FALSE** statement about the Lewis structure of the peroxide anion, O_2^{2-}.

.

A) The oxygen-oxygen bond is a single bond.
B) Each oxygen obeys the octet rule.
C) Each oxygen has a formal charge of –1.
D) Two resonance forms are required to describe the bonding.
E) Each oxygen has 3 nonbonding electron pairs.

Name: _____ Student number: _____

Extra space for rough work:

Name: _____ Student number: _____

Extra space for rough work:

Name: _____ Student number: _____

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

$R = 8.3145\ \text{J K}^{-1}\ \text{mol}^{-1} = 0.08206\ \text{L atm K}^{-1}\ \text{mol}^{-1}$

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

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

Specific heat of $H_2O(s) = 2.03\ \text{J / g·°C}$

Specific heat of $H_2O(l) = 4.18\ \text{J / g·°C}$

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

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

density(H_2O, l) = 1.00g/mL

$\Delta H^{o}_{fus}[H_2O] = 6.01\ \text{kJ mol}^{-1}$

$\Delta H^{o}_{vap}[H_2O] = 44.0\ \text{kJ mol}^{-1}$

1 atm = 101.325 kPa = 760 mm Hg

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

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

1 Hz = 1 cycle/s

0°C = 273.15 K

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

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

De Broglie wavelength:

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

Hydrogen atom energy levels:

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

Solubility Guidelines for Common Ionic Solids

TABLE 5.1 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 (with some exceptions for Li^+) and the NH_4^+ cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

Name: _____ Student number: _____

END OF EXAM