Name: _____ Student number: _____

Chemistry 1A03 **VERSION 1** **Nov 9, 2018**

McMaster University **Test 2**

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Duration: 120 minutes

This test contains 21 numbered pages printed on both sides. There are **30** multiple-choice questions appearing on pages numbered 3 to 17. Pages 18 and 19 are extra space for rough work. Page 20 includes some useful data and equations, and there is a periodic table on page 21. 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 30. 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 MS or 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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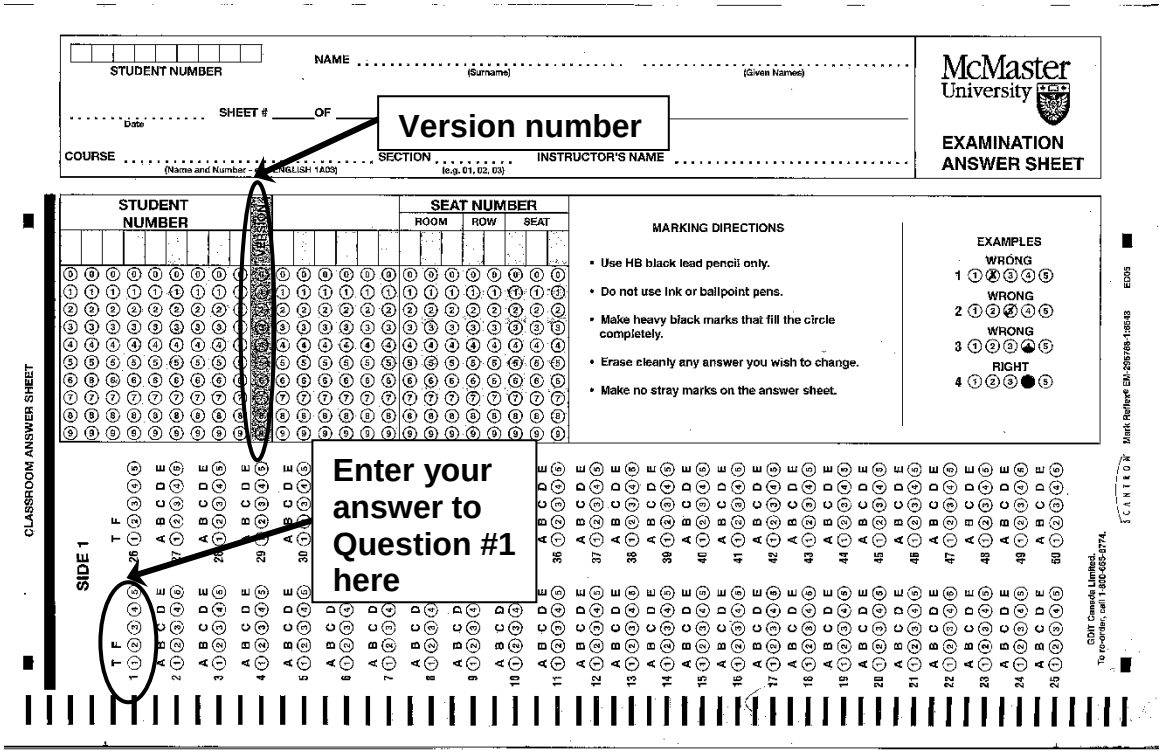
OMR EXAMINATION – STUDENT INSTRUCTIONS

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



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1. Which one of the following equilibrium constant expressions is **incorrect** based on the equilibrium reaction shown?

	Equilibrium reaction	Equilibrium constant
A)	$H_2(g) + Cu^{2+}(aq) \rightleftarrows 2H^+(aq) + Cu(s)$	$K = \frac{[H^+]^2}{P(H_2)[Cu^{2+}]}$
B)	$S(aq) \rightleftarrows S(org)$	$K = \frac{[S(aq)]}{[S(org)]}$
C)	$NH_3(g) + HNO_3(g) \rightleftarrows NH_4NO_3(s)$	$K = \frac{1}{P(NH_3)P(HNO_3)}$
D)	$CaCO_3(s) \rightleftarrows CaO(s) + CO_2(g)$	$K = P(CO_2)$

2. When comparing the elements **Al, Si, P, S, and Cl,** which one of the following statements is **false**?

A) The order of increasing ionization energy is Al < Si < S < P < Cl
B) The order of increasing Z_{eff} for an outermost electron is Al < Si < P < S < Cl
C) The order of increasing magnitude of electron affinity is Al < Si < S < P < Cl
D) The order of increasing atomic radius is Cl < S < P < Si < Al

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3. When arranging the species below from largest to smallest radius, which one is in the **middle**?

O^{2-}, Cl^{-}, Li^{+}, Na^{+}, Al^{3+}

A) Li^{+}
B) Na^{+}
C) Cl^{-}
D) Al^{3+}

4. An orbital has the following quantum numbers:

$n = 6$, $\ell = ?$, $m_\ell = 4$

What could be the missing value(s) for the ℓ quantum number?

A) 5 only
B) 0, 1, 2, 3, 4, or 5
C) 4 or 5
D) 4, 5, or 6

5. The empirical formula of a compound is CH_2. At 125 °C, 0.445 g of this compound in the gas phase occupies a volume of 350. mL at a pressure of 1.00 bar. **What is the molecular formula** of this compound?

A) C_4H_8
B) C_3H_6
C) C_2H_4
D) C_5H_{10}

6. An electron in a hydrogen atom undergoes a transition from $n = 4$ to $n = 2$. **How many** of the following statements are **true**?

I. The transition results in emission of a photon.
II. The atom resulting from this transition is in an excited state.
III. The frequency of light involved in this transition is lower than the frequency of light for the transition from $n = 3$ to $n = 1$.

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

7. What is the **molecular geometry** of IF_5?

A) See-saw
B) Trigonal bipyramidal
C) Square pyramidal
D) Octahedral

8. A stable, diamagnetic molecule, **EF_3**, has a **T-shaped** molecular geometry. Which one of the following could be the **identity of element E**?

A) P
B) Te
C) F
D) Br

9. Which one of the following molecules is **non-polar**?

	Molecule	Molecular geometry
A)	XeF_4	square planar
B)	CF_2Cl_2	tetrahedral
C)	SF_5Cl	octahedral
D)	SF_4	see-saw

10. Which one of the following statements about a BH_2^- anion is **false**?

A) The BH_2^- anion contains only one lone pair
B) The H–B–H angle is slightly greater than 120°
C) Boron in BH_2^- has less than an octet of valence electrons
D) The BH_2^- anion has a negative formal charge on boron

11. Which one of the following compounds has bonds with the **most covalent character**?

A) ClF
B) AlF_3
C) MgF_2
D) BF_3

12. Which one of the following statements about the NO^+ ion is **false**?

A) The formal charge on the nitrogen atom in both NO^+ and nitrate anion is the same
B) The NO^+ ion has two lone pairs
C) NO^+ is a polar molecule
D) The average N–O bond length is shorter in NO^+ than in a nitrate anion

13. Which one of the following statements about SO_4^{2-}, HSO_4^- and HSO_3^- is **false**?

A) The electron pair geometry for HSO_3^- is the same as that of HSO_4^-
B) There are 9 lone pairs in HSO_4^-
C) The average formal charge on the terminal oxygen atoms is more negative for HSO_3^- than HSO_4^-
D) The average bond order for the terminal sulphur–oxygen bonds is higher for SO_4^{2-} than HSO_3^-

14. Determine the pH of a saturated solution of iron(II) hydroxide ($K_{sp} = 8.0 \times 10^{-16}$).

A) 8.98
B) 7.85
C) 9.07
D) 7.53

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15. Determine the **molar solubility** of strontium fluoride ($K_{sp} = 2.5 \times 10^{-9}$) in a 0.10 M solution of $Sr(NO_3)_2$.

A) 8.6×10^{-4}
B) 1.8×10^{-4}
C) 7.9×10^{-5}
D) 5.0×10^{-5}

16. For the synthesis of ammonia at 573 K:

$$3\ H_2(g) + N_2(g) \rightleftarrows 2\ NH_3(g) \qquad K = 4.3 \times 10^{-3}$$

A reaction mixture contains 19.0 bar NH_3, 28.6 bar H_2 and 9.53 bar N_2 in a 5.0 L flask at 573 K. Which statement is **true**?

A) Q > K and the reaction shifts to the left
B) Q > K and the reaction shifts to the right
C) Q < K and the reaction shifts to the left
D) Q < K and the reaction shifts to the right

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17. The reaction $3\ H_2(g) + N_2(g) \rightleftarrows 2\ NH_3(g)$ is exothermic, with $K = 4.3 \times 10^{-3}$ at 573 K. A vessel contains N_2, H_2 and NH_3 at equilibrium at 573 K. Which one of the following changes will cause the **equilibrium constant to increase**?

A) Adding more NH_3 to the vessel.
B) Adding more N_2 to the vessel.
C) Decreasing the temperature of the vessel.
D) Decreasing the volume of the vessel.

18. Consider the reaction: $A_2(g) \rightleftarrows 2\ A(g)$.

A flask is charged with 1.50 bar A_2 and 1.80 bar A and maintained at a constant temperature. When equilibrium is achieved, the partial pressure of A is 1.70 bar. What is the **equilibrium constant** at this temperature?

A) 1.06
B) 1.86
C) 1.21
D) 1.81

19. If 1 mole of each the following salts were placed in separate beakers each containing 1 L of water, which one would have the **greatest conductivity**?

A) K_3PO_4
B) $Fe_2(SO_4)_3$
C) NH_4NO_3
D) $MgCO_3$

20. **How many** of the following ionic compounds would generate a **basic solution** when dissolved in water?

NH_4Cl, NaHCOO, NaCl, KNO_3

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

21. The pH of a 1 M aqueous solution of an acid at room temperature is found to be 5.3. What is the relationship between **K_a of the acid and K_b of its conjugate base**?

A) The relationship between K_a and K_b cannot be determined from the given information
B) $K_a = K_b$
C) $K_a < K_b$
D) $K_a > K_b$

22. Which term best describes **BCl_3**?

A) Lewis Acid
B) Bronsted-Lowry Acid
C) Bronsted-Lowry Base
D) Lewis Base

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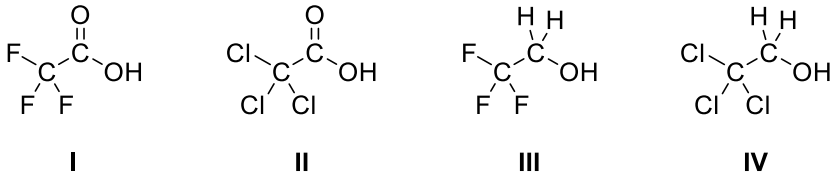
23. Butanoic Acid (MW = 88.11 g mol^{-1}) is a monoprotic acid with $K_a = 1.5 \times 10^{-5}$. Calculate the **percent ionization** of butanoic acid when 5.3 g is added to 450 mL of water.

A) 1.1%
B) 13%
C) 0.0020%
D) 0.14%

24. Rank the following species according to **increasing K_a**, from lowest K_a to highest K_a.



A) IV < II < III < I
B) III < IV < I < II
C) I < II < III < IV
D) IV < III < II < I

25. How many **grams of calcium hydroxide** would be required to completely neutralize an 80.0 mL solution of 0.650 M of hydrochloric acid?

A) 1.93 g
B) 0.0260 g
C) 0.0520 g
D) 3.86 g

26. **Rank** the following oxyacids from **least acidic** to **most acidic**.

$HClO_2$, HBrO, HClO

A) $HClO < HBrO < HClO_2$
B) $HClO_2 < HClO < HBrO$
C) $HClO_2 < HBrO < HClO$
D) $HBrO < HClO < HClO_2$

27. A gas undergoes a process in which it does 89 J of work on the surroundings and absorbs 567 J of heat. **What is the total change in internal energy, in J**, for the gas?

A) + 478 J
B) + 656 J
C) – 478 J
D) – 656 J

28. **Balance** the following reactions, and then determine **how many** of these reactions demonstrate work being done *on* the system *by* the surroundings.

$CO\ (g) + O_2\ (g) \rightarrow CO_2\ (g)$ (unbalanced)

$PH_3BCl_3(s) \rightarrow PH_3(g) + BCl_3(g)$ (unbalanced)

$C_6H_6\ (l) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$ (unbalanced)

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

29. During experiment 2, Cycles of Copper, a student obtains a percent yield/recovery that is more than 100%. Which of the following observations is **NOT a plausible cause of inflated yield** for this experiment?

A) The final product was slightly damp and smelled of acetone when its mass was recorded.
B) The student skipped the step that asked them to add HCl to the beaker.
C) After adding the Zn, the solution was still faintly blue before the copper product was rinsed and dried.
D) The actual mass of Cu(s) reacted was 0.2031 g, but the student accidentally used a value of 0.2013 g in their calculations.

30. During experiment 1, a titration of HCl(aq) with NaOH(aq) was completed. How many of the following mistakes would have **an impact on the accurate determination of the [NaOH]**?

I. Adding water to the titration flask after pipetting in 10.00 mL of HCl
II. Allowing some HCl to drip out of the pipette onto the lab bench before transferring to the Erlenmeyer flask
III. Leaving water in the beaker when collecting the stock HCl solution.

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

Extra space for rough work

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

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.

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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