Name: _____   Student number: _____

Chemistry 1E03   **Test 2**   **Nov. 9, 2012**

McMaster University   *VERSION 1*

Instructors: Dr. R. Dumont

Duration: 120 minutes

This test contains 18 numbered pages printed on both sides. There are **30** multiple-choice questions appearing on pages numbered 3 to 14. Pages 15 and 16 provide extra space for rough work. Page 17 includes some useful data and equations, and there is a periodic table on page 18. 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 60. There is **no** additional 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 <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; 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, ~~(section number, instructor 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** (~~and course section number~~) in the space provided and <u>fill in the corresponding bubble numbers underneath</u>.

3. Answers: mark only **ONE** choice from the alternatives (~~1,2,3,4,5 or~~ A,B,C,D,E) provided for each question. ~~If there is a True/False question, enter response o 1 (or A) as True, and 2 (or B) as False.~~ 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".

1. Dichromate ions, $Cr_2O_7{}^{2-}$(aq), react with zinc metal in acid solution to produce Cr^{3+}(aq) and Zn^{2+}(aq) ions. When the reaction is balanced, such that the smallest possible integers appear as stoichiometric coefficients, the coefficient for Zn^{2+} is:
.
   A) 2
   B) 3
   C) 6
   D) 1
   E) 4

2. From the following thermochemical data, what is $\Delta H_f°$[NO(g)] (in kJ mol^{-1}) ?
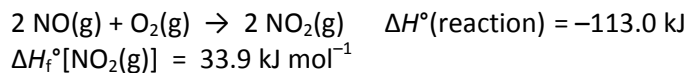
   2 NO(g) + O$_2$(g) → 2 NO$_2$(g) $\Delta H°$(reaction) = −113.0 kJ
   $\Delta H_f°$[NO$_2$(g)] = 33.9 kJ mol^{-1}
   .
   A) +117.1
   B) +90.4
   C) −90.4
   D) +67.2
   E) −67.3

3. Which atom has the **greatest number of *unpaired* electrons** in its ground-state electron configuration?
.
   A) Mn
   B) Ni
   C) N
   D) S
   E) Be

4. Dissolving 3.90 g of CaF_2 in 50.0 mL of pure water (density = 1.00 g mL^{-1}) causes the temperature of the water to decrease from 20.00 to 17.32 °C. What is the **molar enthalpy of dissolution** of CaF_2 (in **kJ mol^{-1}**) ? Assume that the specific heat of the solution equals 4.18 J g^{-1} K^{-1} (use the combined mass of water and solute for mass of solution).

.

A) +10.3
B) +12.1
C) −17.6
D) −12.1
E) +17.6

5. Calculate the **longest wavelength (in μm)** of light **emitted** by an excited hydrogen atom in which the electron occupies the energy level $n = 6$.

.

A) 93.7
B) 7.46
C) 2.28
D) 1.00
E) 3.28

6. A sample weighing 0.6760 g that contains an unknown amount of Ba^{2+} ions was completely dissolved in water and treated with an excess of sodium sulfate, Na_2SO_4. A precipitate of $BaSO_4$ formed which was dried and weighed, yielding 0.4105 g. What is the **mass percentage of barium** in the original sample?

.

A) 27.11
B) 39.46
C) 61.72
D) 53.89
E) 35.73

7. Which **ONE** of the following pairs of reagents produces **no visible** change (i.e. no gas evolution, precipitate formation, or color change)?

  .
  A) $Cl_2(aq) + KBr(aq)$
  B) $Na_2CO_3(s) + HCl(aq)$
  C) $Cu(s) + HCl(aq)$
  D) $KCl(aq) + AgClO_4(aq)$
  E) $Zn(s) + HI(aq)$

8. The empirical formula of a compound is CH. At 200 °C, 0.147 g of this compound in the gas phase occupies a volume of 97.2 mL at a pressure of 0.75 atm. What is the **molecular formula** of the compound?

  .
  A) C_6H_6
  B) C_7H_7
  C) C_5H_5
  D) C_8H_8
  E) C_2H_2

9. Put the following atoms in order of **increasing ionization energy**:

  .
  A) $B < Be < C < F < Na$
  B) $Be < B < C < F < Na$
  C) $Na < Be < C < B < F$
  D) $Na < B < Be < C < F$
  E) $F < C < B < Be < Na$

10. Identify the **FALSE** statement(s):
    (i) Lithium fluoride has a lower melting point than potassium iodide.
    (ii) Magnesium has a larger atomic radius than sodium.
    (iii) For some elements, the 2nd ionization energy ($M^+ \rightarrow M^{2+} + e^-$) is smaller than the 1st ionization energy ($M \rightarrow M^+ + e^-$).
    .
    A) iii only
    B) ii, iii
    C) i, ii, iii
    D) i only
    E) i, iii

11. Which **ONE** of the following statements is **FALSE**?
    .
    A) B has a larger first ionization energy than Al.
    B) S is a smaller atom than Ge.
    C) Be has a larger first ionization energy than Li.
    D) Ca has a larger atomic radius than K.
    E) The ground state electron configuration of P has 3 unpaired electrons.

12. Which of the following statement(s) is(are) **FALSE**?
    (i) Al has a higher first ionization energy than Ga.
    (ii) Ne atoms are smaller than O atoms.
    (iii) K is more easily ionized than Na.
    (iv) HNO_3 is a stronger acid than H_2CO_3.
    (v) O^{2-} is smaller than Na^+.
    .
    A) iii
    B) iv, v
    C) i, ii
    D) iii, iv
    E) v

13. Put the following species in order of **increasing atomic radius**:
.
A) $N < Ne < Al < Si < K$
B) $Ne < K < Al < Si < N$
C) $K < Al < Si < N < Ne$
D) $N < Si < Al < Ne < K$
E) $Ne < N < Si < Al < K$

14. Which one of the following **decreases** across a row of the periodic table, from **left to right**?
.
A)   Atomic radius
B)   Magnitude of electron affinity
C)   Electronegativity
D)   Ionization energy
E)   Effective nuclear charge

15. For the species NO^+, NO_2^-, NO_3^-, what is the correct **order of decreasing** N-O **bond length**?
.
A) $NO_2^- < NO^+ < NO_3^-$
B) $NO_3^- < NO_2^- < NO^+$
C) $NO^+ < NO_3^- < NO_2^-$
D) $NO_3^- < NO^+ < NO_2^-$
E) $NO^+ < NO_2^- < NO_3^-$

16. Given $\Delta H_f°[NF_3(g)] = -132$ kJ mol^{-1} and the following bond enthalpy (D) data: $D(N\equiv N)$ = 946 kJ mol^{-1}, $D(F-F)$ = 159 kJ mol^{-1}, which of the following statements is(are) **FALSE**?

   (i)   The average N–F bond energy in NF$_3$ is 281 kJ mol^{-1}.
   (ii) $\Delta H_f°[NF_3(g)] > \Delta H_f°[NF_3(l)]$
   (iii) $\Delta H_f°[F(g)] = 159$ kJ mol^{-1}
   .
   A)   ii
   B)   ii, iii
   C)   i, iii
   D)   iii
   E)   i

17. Rank the molecules PF$_5$, PF$_3$ and PH$_3$, in order of **increasing molecular dipole moment**? (Electronegativity values: P = 2.1; H = 2.2; F = 4.0)
   .
   A)   PF$_5$ < PF$_3$ < PH$_3$
   B)   PF$_3$ < PF$_5$ < PH$_3$
   C)   PF$_5$ < PH$_3$ < PF$_3$
   D)   PH$_3$ < PF$_3$ < PF$_5$
   E)   PH$_3$ < PF$_5$ < PF$_3$

18. Calculate the **lattice enthalpy** (in kJ mol^{-1}) of potassium iodide from the following data:

    $\Delta H^{o}{}_{f}$ [K(g)] = 89 kJ mol^{-1}
    First ionization energy of K(g) = 418 kJ mol^{-1}
    $\Delta H^{o}{}_{f}$ [I(g)] = 107 kJ mol^{-1}
    Electron affinity of I(g) = 295 kJ mol^{-1}
    $\Delta H^{o}{}_{f}$ [KI(s)] = –328 kJ mol^{-1}
.

A) –1237
B) –1433
C) –681
D) –759
E) –597

19. Rank the species CO_2, CO, $CO_3{}^{2-}$ and $HCO_2{}^-$ in order of **increasing bond enthalpy** of the carbon-oxygen bonds.

.

A) $CO_3{}^{2-} < HCO_2{}^- < CO < CO_2$
B) $CO_3{}^{2-} < HCO_2{}^- < CO_2 < CO$
C) $HCO_2{}^- < CO_3{}^{2-} < CO_2 < CO$
D) $CO < CO_2 < HCO_2{}^- < CO_3{}^{2-}$
E) $CO < CO_3{}^{2-} < HCO_2{}^- < CO_2$

20. C is the central atom in the thiocyanate anion, OCN^-. The **best** Lewis structure has the following **O, C and N formal charges**, respectively:
.
   A) −1, 0, 0
   B) 0, +1, −2
   C) 0, 0, −1
   D) −1, +1, −1
   E) −2, +1, 0

21. Put the following salts in the expected order of increasing magnitude of lattice energy: LiF, KBr, BaS, CaO, $MgCl_2$
.
   A) $KBr < LiF < MgCl_2 < BaS < CaO$
   B) $LiF < MgCl_2 < CaO < KBr < BaS$
   C) $LiF < KBr < MgCl_2 < CaO < BaS$
   D) $MgCl_2 < BaS < CaO < LiF < KBr$
   E) $KBr < LiF < CaO < BaS < MgCl_2$

22. Which one of the following species has an **unpaired electron**?
.
   A) ClO
   B) ICl_2^+
   C) I_3^-
   D) NO_2^+
   E) ClO_2^-

23. Which **two** of the following statements are **FALSE**?

    (i) ClF_3 is T-shaped.
    (ii)   The chlorine atom in ClF_3 has three nonbonded electrons pairs.
    (iii)   The average bond order in NO_3^- is 4/3.
    (iv) NO_3^- is trigonal pyramidal.
    (v)   The formal charge on N in NO_3^- is +1.
    .

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

24. For the heterogeneous reaction: $CaCO_3(s) \rightleftarrows CaO(s) + CO_2(g)$, the equilibrium constant at 112ºC is $K = 0.220$.   If the partial pressure of $CO_2(g)$ is 0.50 atm at this same temperature, which **one** of the following statements is **TRUE**?
    .

    A) $Q < K$, the reaction will proceed to the left.
    B) $Q > K$, the reaction will proceed to the left.
    C) $Q < K$, the reaction will proceed to the right.
    D) $Q = K$, the system is at equilibrium.
    E) $Q > K$, the reaction will proceed to the right.

25. Select the **one FALSE** statement concerning the equilibrium $MgCO_3(s) \rightleftarrows MgO(s) + CO_2(g)$ for which $\Delta H° = 100.6$ kJ.

.

A)   Adding $MgO(s)$ does not change the amount of $MgCO_3(s)$.
B)   Halving the size of the reaction vessel increases the amount of $MgCO_3(s)$.
C)   Doubling the amount of all three species (with the volume of the reaction vessel fixed) has no effect on the equilibrium.
D)   Increasing the temperature increases the amount of $MgO(s)$.
E)   Removing $CO_2(g)$ increases the amount of $MgO(s)$.

26. Pure $NOBr(g)$ is introduced in an evacuated container. It dissociates according to the following equilibrium:
$$2\ NOBr(g) \rightleftarrows 2\ NO(g) + Br_2(g)$$
When equilibrium is established at 25 °C, NOBr is 34% dissociated and the total equilibrium pressure P is 0.25 atm. What is K (i.e. K_p) for this equilibrium?
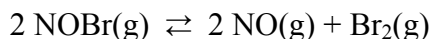
.

A)   0.0096
B) 7.8×10^{-6}
C)   0.016
D)   0.083
E)   0.29

27. A vessel is filled with $N_2O_4(g)$ to an initial pressure of 3.01 atm. Some of this gas decomposes into $NO_2(g)$. At equilibrium, the partial pressure of $N_2O_4(g)$ is found to be 2.71 atm. What is the value of the equilibrium constant for the decomposition of $N_2O_4(g)$ into $NO_2(g)$, at the temperature of this experiment?
.

   A) 0.216
   B) 0.132
   C) 1.43
   D) 3.47
   E) 1.59

28. Given that K_{sp} for CaF_2 is 5.3×10^{-9}, determine the **molar solubility** of CaF_2 in mol L^{-1}.
.

   A) 1.7×10^{-4}
   B) 0.0011
   C) 6.1×10^{-9}
   D) 0.021
   E) 2.3×10^{-3}

29. At 125°C, $K = 0.25$ for the decomposition of sodium hydrogen carbonate,
$$2\ NaHCO_3(s) \rightleftarrows Na_2CO_3(s) + CO_2(g) + H_2O(g).$$
If 10.0 g are added to a 1.00 L flask which is then heated to 125°C, what is the partial pressure of CO_2 in the flask when the reaction comes to equilibrium?
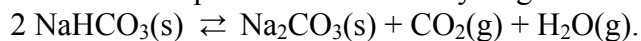
.

A) 0.75 atm
B) 0.50 atm
C) 1.25 atm
D) 1.0 atm
E) 0.25 atm

30. Which **one** of the following equilibria is **unaffected** when the volume of the reaction vessel is **doubled**?

.

A) $PCl_5(g) \rightleftarrows PCl_3(g) + Cl_2(g)$
B) $2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g)$
C) $N_2(g) + O_2(g) \rightleftarrows 2\ NO(g)$
D) $2\ NO_2(g) + 7\ H_2(g) \rightleftarrows 2\ NH_3(g) + 4\ H_2O(l)$
E) $Br_2(g) \rightleftarrows 2\ Br(g)$

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.**

STP = 273.15 K, 1 atm

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

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

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

Specific heat of water = 4.184 J / g·°C

$H°_{vap}[H_2O] = 44.0$ kJ mol^{-1}

$F = 96485$ C/mol

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

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

density(H_2O, l) = 1.00g/mL

1 atm = 101.325 kPa = 760 mm Hg

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 = 10^9 nm = 10^{10} Å

1 g = 10^3 mg

De Broglie wavelength:

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

Hydrogen atom energy levels:

$E_n = -R_H / n^2 = -2.178 \times 10^{-18}$ J / n^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: $\quad\quad \Delta S = \dfrac{q_{rev}}{T}$

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.

PERIODIC TABLE OF THE ELEMENTS

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.

H 1.0079																	**He** 4.0026
Li 6.941	**Be** 9.0122											**B** 10.811	**C** 12.011	**N** 14.007	**O** 15.999	**F** 18.998	**Ne** 20.180
Na 22.990	**Mg** 24.305											**Al** 26.982	**Si** 28.086	**P** 30.974	**S** 32.066	**Cl** 35.453	**Ar** 39.948
K 39.098	**Ca** 40.078	**Sc** 44.956	**Ti** 47.88	**V** 50.942	**Cr** 51.996	**Mn** 54.938	**Fe** 55.847	**Co** 58.933	**Ni** 58.69	**Cu** 63.546	**Zn** 65.39	**Ga** 69.723	**Ge** 72.61	**As** 74.922	**Se** 78.96	**Br** 79.904	**Kr** 83.80
Rb 85.468	**Sr** 87.62	**Y** 88.906	**Zr** 91.224	**Nb** 92.906	**Mo** 95.94	**Tc** [98]	**Ru** 101.07	**Rh** 102.91	**Pd** 105.42	**Ag** 107.87	**Cd** 112.41	**In** 114.82	**Sn** 118.71	**Sb** 121.75	**Te** 127.60	**I** 126.90	**Xe** 131.29
Cs 132.91	**Ba** 137.33	*La 138.91	**Hf** 178.49	**Ta** 180.95	**W** 183.85	**Re** 186.21	**Os** 190.2	**Ir** 192.22	**Pt** 195.08	**Au** 196.97	**Hg** 200.59	**Tl** 204.38	**Pb** 207.2	**Bi** 208.98	**Po** [209]	**At** [210]	**Rn** [222]
Fr [223]	**Ra** 226.03	**Ac 227.03	**Unq** [261]	**Unp** [262]	**Unh** [263]												

Transition Metals

* Lanthanides

Ce 140.12	**Pr** 140.91	**Nd** 144.24	**Pm** [145]	**Sm** 150.36	**Eu** 151.97	**Gd** 157.25	**Tb** 158.93	**Dy** 162.50	**Ho** 164.93	**Er** 167.26	**Tm** 168.93	**Yb** 173.04	**Lu** 174.97

** Actinides

Th 232.04	**Pa** 231.04	**U** 238.03	**Np** 237.05	**Pu** [244]	**Am** [243]	**Cm** [247]	**Bk** [247]	**Cf** [251]	**Es** [252]	**Fm** [257]	**Md** [258]	**No** [259]	**Lr** [262]

END OF EXAM