Name: _____ **Student number: _____**

Chemistry 1E03 **Test 2** **Nov. 10, 2017**

McMaster University ***VERSION 1***

Instructors: Drs. R.S. Dumont, P. Kruse & L. Davis

Duration: 120 minutes

This test contains 18 numbered pages printed on both sides. There are **25** 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 1 mark; the total marks available are 25. 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. Keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy answers.

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.

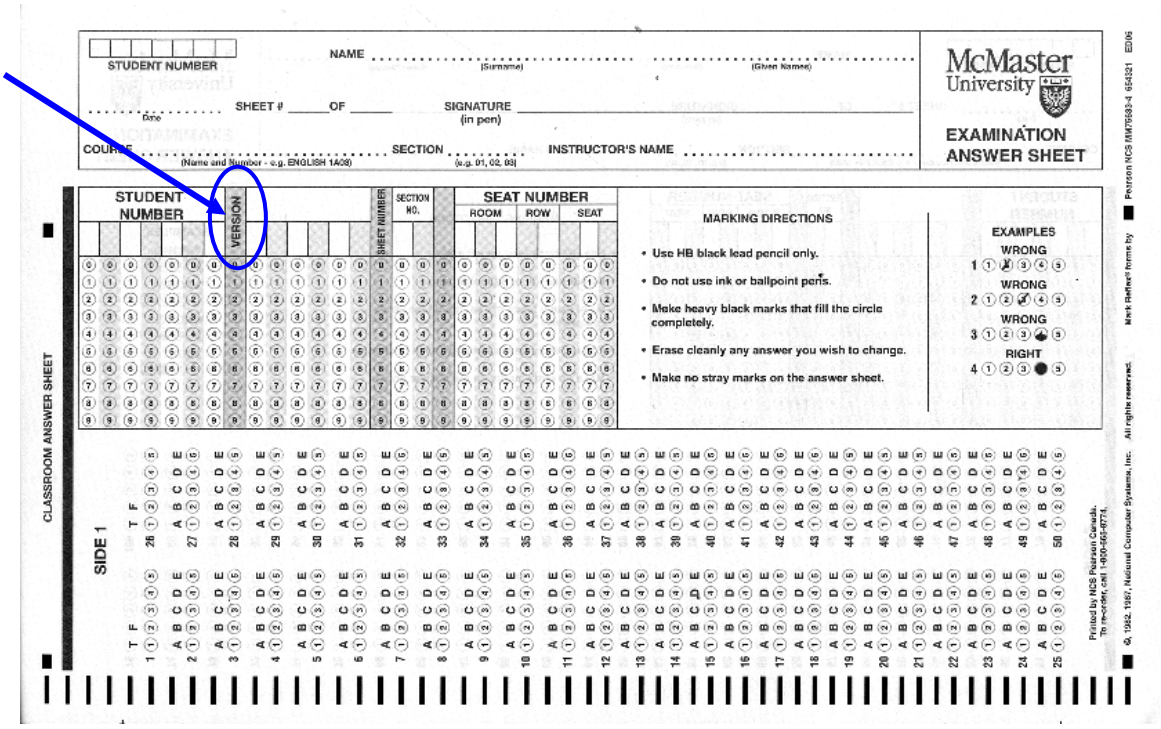
Name: _____ Student number: _____

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 **fill in the corresponding bubble numbers underneath**.
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. Which of the following statements are **FALSE** according to the shapes predicted by the VSEPR model? (Central atoms are underlined.)

(i) $\underline{As}H_3$ and $\underline{Br}O_3^-$ have the same shape.
(ii) $\underline{I}Cl_4^+$ is tetrahedral.
(iii) $\underline{I}Cl_4^-$ is square-planar.
(iv) $\underline{O}F_2$ has a smaller permanent dipole moment than $\underline{Xe}F_2$.
(v) $\underline{N}O_2$ is a non-polar molecule.

.

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

2. How many **non-bonding electrons** are there in the charge-minimized Lewis structure for the dihydrogen phosphate ion, $H_2PO_4^-$? (In the Lewis structure P is the central atom, and is bonded only to O).

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A) 6
B) 10
C) 18
D) 20
E) 14

3. According to the VSEPR model, which one of the following molecules should be **linear**? (Central atoms are underlined)

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A) $H_2\underline{C}O$
B) $\underline{B}F_3$
C) $\underline{S}O_2$
D) H$\underline{C}$N
E) $H_2\underline{S}$

4. **Rank** the species CO_2, CO, CO_3^{2-} and HCO_2^- in order of **increasing bond order** of the carbon-oxygen bonds. For each species, carbon is the central atom.

.

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

5. Which one of the following molecules has **no** net dipole moment? (Central atoms are underlined)

.

A) $\underline{N}F_3$
B) $\underline{S}O_3$
C) $\underline{N}O_2$
D) $\underline{C}H_3Cl$
E) $H_2\underline{Se}$

6. Which of the following statements are **FALSE** about the BrO_2F molecule? (Br is the central atom)

(i) It has a permanent dipole moment.
(ii) It is T-shaped about Br.
(iii) There is one lone pair of electrons on Br.
(iv) The octet rule is violated at Br.
(v) The oxidation number of Br is +5.
(vi) The average Br-O bond order is 1.5.

.

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

7. During experiment 2, Cycles of Copper, a student obtains a percent yield/recovery that is less than 100%. Which of the following observations is **NOT a plausible explanation** for this result?

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A) The final product was slightly damp and smelled of acetone when its mass was recorded.
B) Small amounts of CuO(s) were lost during the decanting step.
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 0.2013 g, but the student accidentally used a value of 0.2031 g in their calculations
E) Despite the addition of the H_2SO_4, some black precipitate was present when Zn(s) was added to the reaction beaker.

8. When the following pairs of solutions are mixed, which produces the **strongest electrolyte** solution?

.

A) $Zn(NO_3)_2$ (1 M) + $AgClO_4$ (2 M)
B) $Ba(OH)_2$ (3 M) + $CuSO_4$ (3 M)
C) $Pb(CH_3COO)_2$ (1 M) + NaI (2 M)
D) KCl (1 M) + NH_4NO_3 (1 M)
E) HCl (2 M) + NaOH (2 M)

9. Balance the following redox reaction in **basic** solution.

$$Cr(OH)_3(s) + ClO^-(aq) + OH^-(aq) \rightarrow CrO_4^{2-}(aq) + Cl^-(aq) + H_2O(l)$$

When this has been done correctly, the stoichiometric **coefficients** for the **reactant** species, in order from **left** to **right** are as follows:

.

A) 1, 2, 3
B) 2, 4, 6
C) 3, 4, 5
D) 2, 3, 4
E) 2, 3, 7

10. The following equilibria are **all** shifted towards products:

$$H_2SO_3(aq) + F^-(aq) \rightleftharpoons HSO_3^-(aq) + HF(aq)$$
$$NH_3(aq) + HOCl(aq) \rightleftharpoons NH_4^+(aq) + OCl^-(aq)$$
$$OCl^-(aq) + HF(aq) \rightleftharpoons HOCl(aq) + F^-(aq)$$

Order the **acids** in these reactions according to **increasing** strength as acids.

.

A) $H_2SO_3 < HOCl < NH_4^+ < HF$
B) $HSO_3^- < F^- < OCl^- < NH_3$
C) $OCl^- < NH_4^+ < HF < HSO_3^-$
D) $HOCl < NH_4^+ < H_2SO_3 < HF$
E) $NH_4^+ < HOCl < HF < H_2SO_3$

11. Identify the **TRUE** statement about the reactions of metallic Zn:
.

A) Zn(s) dissolves in water at room temperature.
B) Zn(s) dissolves in hydrochloric acid and chlorine gas is produced.
C) Zn(s) dissolves in nitric acid and hydrogen gas is produced.
D) Zn(s) dissolves in nitric acid and nitric oxide is produced.
E) In the reaction with copper sulphate solution, Zn(s) acts as the oxidizing agent.

12. Which of the following is a **Brønsted-Lowry acid-base** reaction?
.

A) $HSO_4^-(aq) + H_2O(l) \rightarrow H_3O^+(aq) + SO_4^{2-}(aq)$
B) $Ca(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2(g)$
C) $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$
D) $Cu(s) + 4\ HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ NO_2(g) + 2\ H_2O(l)$
E) $2\ K_3PO_4(aq) + 3\ Pb(NO_3)_2(aq) \rightarrow Pb_3(PO_4)_2(s) + 6\ KNO_3(aq)$

13. Which **one** of the following will oxidize $H_2S(g)$?
.

A) Na(s)
B) HBr(aq)
C) $NH_3(g)$
D) $KMnO_4(aq)$
E) $H_2(g)$

14. For the gas phase reaction, $2\ NO(g) + O_2(g) \rightleftharpoons 2\ NO_2(g)$, the expression for the **reaction quotient**, *Q*, is as follows:

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A) $Q = P(NO_2) / P(NO)\ P(O_2)$
B) $Q = P(NO_2)^2 / P(NO)^2\ P(O_2)$
C) $Q = P(NO)^2\ P(O_2) / P(NO_2)^2$
D) $Q = P(NO_2)^2$
E) $Q = P(NO)^2\ P(O_2)$

15. Which of the following changes will **not** affect the following equilibrium?
$Pb(s) + Ni^{2+}(aq) \rightleftharpoons Pb^{2+}(aq) + Ni(s) \qquad \Delta H = 52.3\ kJ\ mol^{-1}$

i. Decrease the temperature
ii. Add $Pb(NO_3)_2(aq)$
iii. Add Ni(s)
iv. Add NaI(aq)
v. Add $H_2O(l)$

.

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

16. Choose the **FALSE** statements regarding chemical equilibrium.

(i) When the reaction quotient is greater than the equilibrium constant, there is net reverse reaction.

(ii) Increasing the temperature always increases the equilibrium constant.

(iii) When the system has reached equilibrium, the molecules stop reacting.

(iv) When the system has reached equilibrium, the concentrations of products and reactants stop changing.

.

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

17. At 25°C, the following reactions have the equilibrium constants noted to the right of their equations:

$2\ CO\ (g) + O_2\ (g) \rightleftharpoons 2\ CO_2\ (g) \qquad K = 1.3 \times 10^{90}$

$2\ H_2\ (g) + O_2\ (g) \rightleftharpoons 2\ H_2O\ (g) \qquad K = 3.7 \times 10^{79}$

Determine *K* for the following reaction:

$$H_2O\ (g) + CO\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$$

.

A) 3.6×10^{10}
B) 1.9×10^{5}
C) 3.2×10^{5}
D) 5.3×10^{-6}
E) 1.8×10^{10}

18. At 250°C, a reaction vessel contains $PCl_3(g)$, $Cl_2(g)$ and $PCl_5(g)$ at equilibrium. The associated partial pressures are 0.867 bar, 0.867 bar and 1.34 bar, in the given order. Determine the **equilibrium constant**, *K*, for the reaction,

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

.

A) 0.855
B) -1.30
C) 0.561
D) 9.71
E) 1.78

19. A vessel is filled will 1.00 bar partial pressure of nitrogen gas, and 3.00 bar hydrogen gas, and allowed to equilibrate at 573 K. Ammonia forms according to the balanced reaction,

$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)\ .$$

K = 0.0042 for this reaction at 573 K. What is the **partial pressure** of ammonia (in bar) at **equilibrium**?

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A) 0.069
B) 0.26
C) 0.79
D) 1.19
E) 1.7

20. The first step in the industrial manufacture of nitric acid is the combustion of ammonia. Use the standard formation enthalpies given to calculate the standard enthalpy change, $\Delta H°$ (in kJ), for the reaction:

$$4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O(l)$$

Substance	$NH_3(g)$	$NO_2(g)$	$H_2O(l)$
$\Delta H_f°$ / kJ·mol^{-1}	–46	+34	–286

.

A) –1764
B) –1668
C) –824
D) –206
E) –1396

21. In an ice calorimeter, 15.0 mL of 2.00 M $Ba(NO_3)_2(aq)$ are added to 15.0 mL of 2.00 M $Na_2SO_4(aq)$. The reaction causes 2.34 grams of ice to melt. What is $\boldsymbol{\Delta H°}$ (in kJ mol^{-1}) for the **precipitation of $BaSO_4$** at 0°C? $\Delta H_{fus}°(H_2O)$ = 333 J g^{-1}.

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A) +78.1
B) +26.0
C) –78.1
D) –142
E) –26.0

22. Choose the one **FALSE** statement from among the following:

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A) $\Delta H_f°[CO_2(g)] > \Delta H_f° [CO_2(s)]$
B) $\Delta H_f°$ for some compounds is positive, while for others it is negative.
C) Doing work on a gas increases its volume.
D) All diatomic molecules have molar heat capacities that are larger than their specific heat capacities.
E) The enthalpy change for $O_2(g) \rightarrow 2\ O(g)$ is positive.

23. Given $\Delta H_f°[(NF_3(g)] = -132$ kJ mol^{-1} and the bond enthalpy (D) data, $D(N_2) = 946$ kJ mol^{-1} and $D(F_2) = 159$ kJ mol^{-1}, which of the following statements is/are **FALSE**?

(i) The average N-F bond enthalpy 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) i, iii
C) ii, iii
D) i
E) iii

24. In which of the following processes does the system do work on the surroundings?

(i) $2\ NH_3(g) + 3\ N_2O(g) \rightarrow 4\ N_2(g) + 3\ H_2O(l)$

(ii) $N_2H_4(l) + H_2O(l) \rightarrow N_2O(g) + 3\ H_2(g)$

(iii) $N_2H_4(l) + H_2O(l) \rightarrow 2\ NH_3(g) + 1/2\ O_2(g)$

(iv) $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(l)$

(v) $N_2(g) + 2\ H_2O(l) \rightarrow N_2H_4(l) + O_2(g)$

.

A) all
B) i, ii, iii, v
C) i, iv
D) none
E) ii, iii

25. Fructose, $C_6H_{12}O_6(s)$, is a sugar closely related to glucose. A 0.755 g sample of fructose was combusted with excess oxygen in a bomb calorimeter, containing 500.0 g of water. The heat capacity of the empty calorimeter was 208 J/K. The temperature of the calorimeter and the water rose from 22.00°C to 27.12°C due to the combustion reaction, which formed $CO_2(g)$ and liquid water. What is the **energy change**, ΔU (in kJ mol^{-1}), for the combustion of one mole of fructose?

.

A) –804
B) –2810
C) –15600
D) +254
E) +520

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.**

$R = 8.3145\ \text{J K}^{-1}\ \text{mol}^{-1} = 0.083145\ \text{L bar K}^{-1}\ \text{mol}^{-1}$

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

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

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

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

1 bar = 100.0 kPa

0°C = 273.15 K

$1\ \text{J} = 1\ \text{kg m}^2\ \text{s}^{-2} = 0.01\ \text{L bar} = 1\ \text{Pa m}^3$

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

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

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

1 Hz = 1 cycle/s

Density of water:

$1.00\ \text{g mL}^{-1}$

Specific heat capacity of water:

$4.18\ \text{J K}^{-1}\ \text{g}^{-1}$

Solubility Guidelines for Common Ionic Solids

1. Alkali metal and ammonium salts are *soluble*.
2. Nitrate, chlorate, perchlorate, hydrogen carbonate and ethanoate salts are *soluble*.
3. Sulfate salts are *soluble*, *except* for the calcium, strontium, barium and lead salts which are *insoluble*.
4. Chloride, bromide and iodide salts are *soluble*, *except* for the silver, lead and mercury I salts which are *insoluble*.
5. Silver, lead and mercury I salts are *insoluble*, unless deemed soluble by rule 2 or 3.
6. Sulfide salts are *insoluble*, *except* for the alkali metal, ammonium, and alkaline earth salts which are *soluble*.
7. Oxide and hydroxide salts are *insoluble*, *except* for the alkali metal, ammonium, calcium, strontium and barium salts which are soluble.
8. Carbonate and phosphate are *insoluble*, *except* for the alkali metal and ammonium salts.

Name: _____ Student number: _____

END OF EXAM