Name: _____ Student Number: _____

CHEMISTRY 1A03/1E03 13 OCTOBER 2006

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MCMASTER UNIVERSITY - TERM TEST # 1 - DURATION: 100 minutes

This test contains 16 numbered pages and **25** multiple-choice questions. Page 14 is extra space for rough work. Page 15 includes some useful data and equations, and there is a Periodic Table on page 16. You may tear off the last pages to view the periodic table and the data provided. **You are responsible for ensuring that your copy of the question paper is complete**. Bring any discrepancy to the attention of your invigilator.

Questions 1 to 20 are each worth 2 marks, questions 21–25 are each worth 3 marks. The total marks available are 55. There is **no** additional penalty for incorrect answers.

These question sheets must be returned with your answer sheet. However, no work written on the question sheets will be marked. You must enter your full 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.**

MAKE SURE TO ENTER THE CORRECT VERSION NUMBER OF YOUR TEST (SHOWN AT THE BOTTOM OF EACH PAGE) IN THE CORRECT COLUMN ON THE ANSWER SHEET (SEE INSTRUCTIONS ON PAGE 2).

Answer all questions on the answer sheet, in pencil. Instructions for entering multiple-choice answers are given on page 2. Select **one answer for each question** from the choices (A) through (E).

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.

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. 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.

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QUESTIONS 1–20 ARE WORTH 2 MARKS EACH.

1. $Cl_2(g)$ reacts with a solution of NaBr(aq) by oxidizing bromide ions into bromine, $Br_2(aq)$. What **volume (in mL)** of chlorine gas, measured at 25.00°C and 1.00 atm, is needed to completely react with 25.0 mL of 0.100 M NaBr(aq)?

A) 71.0
B) 30.6
C) 305
D) 15.2
E) 2.56

2. In a lab experiment, a student adds 10.0 mL of a 2.0 M solution of sodium hydroxide to 50.0 mL of a 0.30 M solution of copper(II) nitrate (where II represents the oxidation state of copper). When the reaction reaches completion, what **mass (in grams)** of copper(II) hydroxide is formed? Assume that the only reaction occurring is:

$Cu(NO_3)_2(aq) + 2\ NaOH(aq) \rightarrow Cu(OH)_2(s) + 2\ NaNO_3(aq)$.

A) 1.5
B) 3.9
C) 0.98
D) 2.0
E) 2.9

3. What is the **correct** chemical formula for potassium hydrogensulfate?

A) K_2HSO_4
B) $K(HSO_4)_2$
C) $KHSO_3$
D) K_2SO_3
E) $KHSO_4$

4. How many **grams** of calcium oxide, CaO, can be produced from 4.20 g of calcium metal and 1.60 g of oxygen gas?

A) 5.61
B) 5.88
C) 2.80
D) 5.80
E) 2.94

END OF EXAM

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13. Gray and white tin (Sn) are two allotropes of tin. When $SnO_2(s)$ is formed by the oxidation of *gray* tin by oxygen, the reaction enthalpy is -578.6 kJ, and when $SnO_2(s)$ is formed by the oxidation of *white* tin by oxygen, the reaction enthalpy is -580.7 kJ. Calculate the reaction enthalpy **(in kJ)** for Sn(gray) → Sn(white).

A) -1159.3
B) 0.0
C) +2.1
D) +1159.3
E) -2.1

You are not responsible for this question! (yet!)

14. Which one of the following statements is **false** regarding the following two reactions:
(i) $CO_2(l) \rightarrow CO_2(g)$
(ii) $CO(g) \rightarrow C(g) + O(g)$

A) The molar heat of vaporization of carbon dioxide is ΔH for reaction (i).
B) Reaction (i) is endothermic.
C) Reaction (ii) is endothermic.
D) Both reactions cause work to be done on the surroundings.
E) ΔH for reaction (ii) equals $-\Delta H_f°$ for CO(g).

You are not responsible for this question! (yet!)

15. "Every electron in an atom must have its own unique set of quantum numbers" is a statement associated with:

A) Heisenberg
B) Hund
C) de Broglie
D) Pauli
E) Einstein

16. An electron travelling inside an electron microscope has an associated de Broglie wavelength of 0.0500 Å. Calculate its **velocity (in m s^{-1})** .

A) 1.46×10^{8}
B) 0.730×10^{8}
C) 14.6×10^{6}
D) 0.730×10^{11}
E) 1.46×10^{3}

17. Which ones of the following statements are **false**?
(i) A hydrogen atom absorbs energy when its electron moves from the level n=1 to the level n=3.
(ii) Einstein was the first person to introduce the idea of quantum numbers to explain atomic spectra.
(iii) The frequency of a light wave increases with the energy of the associated photons.
(iv) The wavelength associated with a moving particle is proportional to its mass.

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

18. Identify the **FALSE** statement(s):
(i) (3, 3, -1, -1/2) is a set of (n, l, m_l, m_s) quantum numbers that could describe an electron in a 3d orbital.
(ii) The ground-state electron configuration of the nitride anion (N^{3-}) has three unpaired electrons.
(iii) An Al^{3+} cation in its ground state contains electrons in the shell n = 3.

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

19. Which electron configuration corresponds to an **excited state** of a neutral halogen atom (Group 17 / 7A)?

A) $[Ar]3d^2 4s^2 4p^4$
B) $[Ne]3s^2 3p^1 4s^1$
C) $[Ar]3d^5$
D) $[Kr]4d^{10} 5s^2 5p^5$
E) $[Ne]3s^1 3p^6$

20. 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) 3.28
C) 7.46
D) 1.00
E) 2.28

QUESTIONS 21-25 ARE WORTH 3 MARKS EACH.

21. Dissolving 3.90 g of CaF_2 in 50.0 mL of pure water (density = 1.00 $g \cdot mL^{-1}$) causes the temperature of the water to decrease from 20.00 to 16.79 °C. Calculate the **molar enthalpy of dissolution of CaF_2 (in kJ mol^{-1})**. Assume that the solution has the same specific heat capacity as pure water (4.184 $J \cdot g^{-1} \cdot K^{-1}$).

A) –13.4
B) +1.05
C) –1.05
D) –671
E) +13.4

22. Identify the **correct** statements from among the following:
(i) A 3s orbital has a higher energy than a 2s orbital.
(ii) An electron transition from the level n = 2 to the level n = 1 in a hydrogen atom results in the emission of visible light (wavelength range of 400-750 nm).
(iii) A photon with an energy of 1.988 x 10^{-15} J has a wavelength shorter than 1 nm.
(iv) An electron with a velocity of 7.274 x 10^4 m s^{-1} has a wavelength longer than 1 nm.
(v) The coloration of a flame by metal salts is due to electronic transitions in the non-metal atoms.

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

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23. Which of the following statements is(are) **true**?

(i) In a hydrogen atom, the 3p and 3d sub-shells both correspond to an energy of -2.420×10^{-17} J for the electron.

(ii) $1s^2\ 2s^2\ 2p^3\ 3s^1$ represents the ground-state electron configuration of an oxygen atom.

(iii) In an aluminum atom, electrons in the 3s and 3p orbitals have different energies.

(iv) In the ground state of a fluorine atom, no electron has a magnetic quantum number (m_l) equal to 2.

(v) The Ca^{2+} and S^{2-} ions contain different numbers of electrons.

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

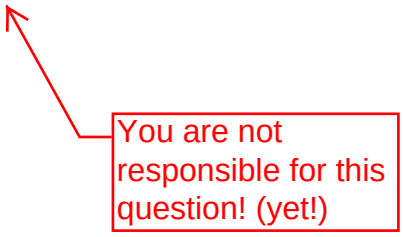
24. Calculate the standard enthalpy of formation, ΔH_f° **(in kJ mol^{-1})**, of solid $Mg(OH)_2$, given the following data:

$2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$ $\quad \Delta H^\circ_1 = -1203.6$ kJ

$Mg(OH)_2(s) \rightarrow MgO(s) + H_2O(l)$ $\quad \Delta H^\circ_2 = +37.1$ kJ

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$ $\quad \Delta H^\circ_3 = -571.7$ kJ

A) +924.7
B) +1849.5
C) -1849.5
D) -462.3
E) -924.7



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

(i) Alkali metal hydrides produce hydrogen gas upon reacting with water.

(ii) Aqueous ammonia is a stronger base than potassium hydroxide.

(iii) Redox reactions between alkali metals (Group 1A) and halogens (Group 7A) produce ionic compounds which are soluble in water.

(iv) Hydrofluoric acid is a stronger acid than hydrochloric acid.

(v) Mixing aqueous phosphoric acid and strontium hydroxide produces no *visible* reaction.

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

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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
$R = 8.3145\ J\ K^{-1}\ mol^{-1} = 0.08206\ L\ atm\ K^{-1}\ mol^{-1}$
$c = 2.9979 \times 10^{8}\ m/s$
$m_e = 9.10 \times 10^{-31}\ kg$
Specific heat of water = 4.184 J / g·°C

$F = 96485\ C/mol$
$N_A = 6.022 \times 10^{23}\ mol^{-1}$
$h = 6.6256 \times 10^{-34}\ Js$
density(H_2O, l) = 1.00g/mL

1 atm = 101.325 kPa
$1\ J = 1\ kg\ m^2\ s^{-2} = 1\ kPa\ L = 1\ Pa\ m^3$
$1\ cm^3 = 1\ mL$
1 Hz = 1 cycle/s

0°C = 273.15 K
$1\ m = 10^9\ nm = 10^{10}$ Å
$1\ g = 10^3\ mg$

$\lambda = h / mv = h / p$
$E_n = -2.178 \times 10^{-18} J / n^2$
$\Delta G = \Delta G^o + RT\ lnQ$
$E = E^o - (RT / nF)\ lnQ = E^o - (0.0257 / n)\ lnQ = E^o - (0.0592 / n)\ logQ$

Soluble Ionic Compounds:

1. All common compounds of Group 1A(1) and ammonium (NH_4^+) ions.
2. All common nitrates (NO_3^-), acetates (CH_3COO^-), and most perchlorates (ClO_4^-).
3. All common chlorides (Cl^-), bromides (Br^-), and iodides (I^-), *except* those of Ag^+, Pb^{2+}, Cu^+, and Hg_2^{2+}.
4. All common sulfates (SO_4^{2-}), *except* those of Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}.

Insoluble Ionic Compounds:

1. All common metal hydroxides (OH^-), *except* those of Group 1A(1) and the heavier members of Group 2A(2) (beginning with Ca^{2+}).
2. All common carbonates (CO_3^{2-}) and phosphates (PO_4^{3-}), *except* those of Group 1A(1) and NH_4^+.
3. All common sulfides (S^{2-}), *except* those of Group 1A(1), Group 2A(2), and NH_4^+.