CHEMISTRY 1E03 **10 OCTOBER 2008**

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

This test contains 15 pages and **25 multiple-choice questions**. The last pages include two extra blank pages for rough work, a page with some useful data and equations, and a Periodic Table. You may tear off the last four pages. **You are responsible for ensuring that your copy of the question paper is complete**. Bring any discrepancy to the attention of your invigilator.

Questions 1-20 are each worth 2 marks, questions 21–25 are each worth 3 marks. There is no 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.

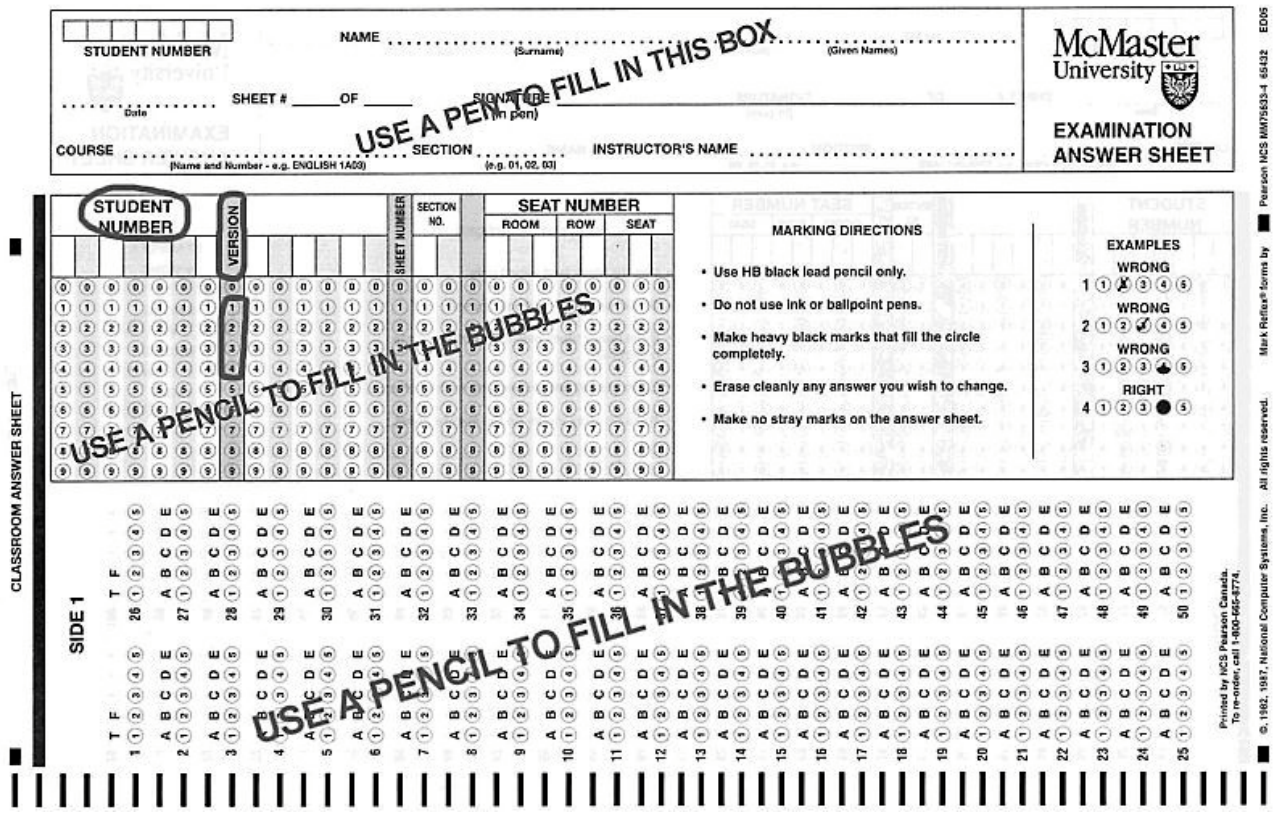
Note: Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, etc.) between students, sharing of materials between students, copying or looking at other students' work. If a problem arises, please ask an invigilator to deal with it for you.

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, print your student number, name, course name, and the date in the spaces provided, *in pen*. Then you **MUST** write your signature, in the space marked SIGNATURE.
2. In the second box, mark your student number and **test or exam version number (1, 2, 3 …)** by filling in the corresponding bubbles underneath, *in pencil*.
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. Begin answering Question # 1 using the first set of bubbles, marked "1".



QUESTIONS 1–20 ARE WORTH 2 MARKS EACH.

1. The percentage by mass of bicarbonate in an Alka-Seltzer tablet is 32.5 %. Calculate the volume of carbon dioxide gas (**in mL**) generated at 37 °C and 1.00 atm from a 3.29 g tablet according to the reaction:

$$HCO_3^-(aq) + H^+(aq) \rightarrow H_2O(l) + CO_2(g)$$

A) 1370
B) 27.2
C) 446
D) 53
E) 618

2. Neutral atoms of ^{16}O, ^{17}O and ^{18}O **all** have:

A) 8 electrons and 8 protons
B) 16 protons
C) 16 protons and 16 electrons
D) 8 neutrons and 8 protons
E) 8 neutrons

3. 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 cobalt(II) nitrate (where II represents the oxidation state of cobalt). When the reaction reaches completion, what **mass (in grams)** of cobalt(II) hydroxide is formed? Assume that the only reaction occurring is:

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

A) 3.9
B) 1.9
C) 2.9
D) 0.93
E) 1.4

4. The density of a noble gas is 2.71 g L^{-1} at 3.00 atm and 0 °C. What is the gas?

A) Xe
B) Kr
C) He
D) Ar
E) Ne

5. Which **one** of the following statements is **false** regarding reactions (i), (ii) and (iii), shown here?
(i) $2NaOH(aq) + NiCl_2(aq) \rightarrow 2\ NaCl(aq) + Ni(OH)_2(s)$
(ii) $PbO_2(aq) + 2HCl(aq) + H_2SO_4(aq) \rightarrow PbSO_4\ (s) + 2H_2O + Cl_2(g)$
(iii) $KOH(aq) + HNO_3(aq) \rightarrow KNO_3(aq) + H_2O(l)$

A) (ii) is an oxidation-reduction reaction.
B) In (iii), HNO_3 acts as an acid.
C) (iii) is a proton-transfer reaction.
D) (i) is a precipitation reaction.
E) In (ii), HCl(aq) acts as an oxidizing agent.

6. After balancing it, which **one** statement is **false** regarding the following chemical equation?
$Cl_2(g) + OH^-(aq) \rightarrow Cl^-(aq) + ClO^-(aq) + H_2O(l)$

A) One mole of $H_2O(l)$ is produced for every mole of $OH^-(aq)$ consumed.
B) The oxidation number of H does not change.
C) This is a disproportionation reaction.
D) One Cl atom in $Cl_2(g)$ decreases its oxidation number, while the other increases its oxidation number.
E) One mole of ClO^- (aq) is produced for every mole of $Cl_2(g)$ consumed.

7. You mix hydrochloric acid with aqueous silver nitrate in a beaker. What **type of reaction** would you expect to occur?

A) proton transfer
B) electron transfer
C) precipitation
D) redox
E) acid-base

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

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

9. Identify the **oxidizing agent** in the following reaction:
$2\ Cr(OH)_3(s) + 3\ ClO^-(aq) + 4\ OH^-(aq) \rightarrow 2\ CrO_4^{2-}(aq) + 3\ Cl^-(aq) + 5\ H_2O(l)$

A) OH^-
B) $Cr(OH)_3$
C) ClO^-
D) Cl^-
E) CrO_4^{2-}

10. Identify the **Brønsted-Lowry acid-base** reaction among the following:

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

11. Which one of the following statements is **false**?

A) When neither energy nor matter can enter or escape a system, it is said to be isolated.
B) The difference between the enthalpy and the energy of a system is an amount PV.
C) Heat flow into a system increases the energy of a system.
D) Energy and enthalpy are both state functions.
E) Work flow out of a system is considered positive.

12. 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) +1.05
B) +2.1
C) -1159.3
D) +1159.3
E) -2.1

13. In which of the following processes is $\Delta H = \Delta U$?

A) Calcium carbonate is heated to form calcium oxide and carbon dioxide in an open container.
B) The reaction $2\ HI(g) \rightarrow H_2(g) + I_2(g)$ occurs in a sealed container at a constant temperature of 400°C.
C) A sample of ammonia gas is cooled from 325°C to 300°C at 1 atm.
D) A sample of solid carbon dioxide (dry ice) sublimes to the gas phase.
E) A sample of steam is condensed into liquid water at 90°C and 1 atm.

14. For the process $He(g) \rightarrow He(l)$ at 4.2 K, which one of the following statements is **false**? (All statements refer to the system.)

A) $\Delta U \neq 0$
B) $q < 0$
C) $w < 0$
D) $\Delta V < 0$
E) $\Delta U \neq \Delta H$

15. Calculate the standard enthalpy of formation (**in kJ mol^{-1}**) for cyclopentane gas, $C_5H_{10}(g)$, using the following reaction enthalpies.

$2\ C_5H_{10}(g) + 15\ O_2(g) \rightarrow 10\ CO_2(g) + 10\ H_2O(l)$	$\Delta H = -3279$ kJ
$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$	$\Delta H = -393.5$ kJ
$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$	$\Delta H = -1144$ kJ

A) +2314
B) +674
C) –6376
D) –774
E) –3188

16. As 20.0 g of solid NH_4NO_3 are dissolved in water to make 100.0 cm^3 of solution, the temperature of the solution changes from 22.3°C to 7.0°C. Calculate the enthalpy of dissolution of NH_4NO_3 (**in kJ mol^{-1}**). Assume that the density and specific heat of the solution are equal to those of pure water (d = 1.00 g·cm^{-3}, c = 4.184 J·g^{-1}·K^{-1}).

A) -30.7
B) -25.6
C) +20.4
D) +25.6
E) +30.7

17. Which **one** of the following statements is **false**?

A) As the principal quantum number, ***n*,** of an orbital increases, so does the average distance between nucleus and electron.
B) Light is emitted when electrons are promoted to higher energy levels.
C) When the orbital quantum number $l = 2$, the possible values of the magnetic quantum number (m_l) are -2, -1, 0, 1, or 2.
D) The photoelectric effect occurs when light strikes the surface of a metal and electrons are ejected.
E) As the wavelength of light increases, the energy decreases.

18. It takes 492 kJ of energy to remove one mole of electrons from the atoms on the surface of solid gold. What is the **maximum wavelength (in nm)** of light capable of doing this?

A) 404
B) 817
C) 743
D) 243
E) 123

19. What is the minimum frequency, in Hz (or s^{-1}), required to ionize hydrogen atoms in their **second excited state** (i.e. when the electron is in the energy level $n = 3$)?

A) 3.66×10^{14}
B) 2.74×10^{-7}
C) 1.10×10^{15}
D) 8.23×10^{14}
E) 3.29×10^{15}

20. Which **one** of the following electron configurations is **not** a ground-state configuration of any neutral atom?

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

QUESTIONS 21-25 ARE WORTH 3 MARKS EACH.

21. One mole of Ar gas is compressed by an external pressure of 2.00 atm, to a final volume of 10.0 L from an initial volume of 20.0 L. Using calorimetry, 1.00 kJ of heat is observed to flow from the gas during the compression. What is the change in energy of the gas**, ΔU (in kJ)**?

A) 3.03
B) –1.03
C) 1.03
D) 2.03
E) –3.03

22. Which of the following statements is(are) **true**?
(i) The ground-state electron configuration of magnesium has no unpaired electron.
(ii) $1s^2\ 2s^2\ 2p^3\ 3s^1$ represents the ground-state electron configuration of an oxygen atom.
(iii) An aluminum atom in its ground state contains 10 core electrons.
(iv) In the ground-state of a fluorine atom, no electron has a magnetic quantum number, m_l, equal to 2.

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

23. When the reaction $MnO_4^-(aq) + I^-(aq) \rightarrow I_2(s) + MnO_2(s)$ is balanced in **basic** solution so that all stoichiometric coefficients are the smallest possible **integers**, the number of electrons transferred and the coefficient for OH^- are (in that order):

A) 3, 12
B) 3, 9
C) 3, 4
D) 6, 4
E) 6, 8

24. The empirical formula of a compound is CH. At 200 °C, 0.145 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_2H_2
B) C_8H_8
C) C_7H_7
D) C_6H_6
E) C_5H_5

25. Identify the **false** statement(s):

(i) The energy of a closed system cannot change.
(ii) For a chemical system to do mechanical work, its volume must decrease.
(iii) The freezing of a pure substance is always an exothermic process.
(iv) The equation $w + q = 0$ expresses the first law of thermodynamics, applied to an isolated system.

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

This page is for rough work only.

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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 = $4.184\ J\ K^{-1}\ g^{-1}$

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

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

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

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

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^+.

Periodic Table of the Elements

- Metals (main-group)
- Metals (transition)
- Metals (inner transition)
- Metalloids
- Nonmetals

MAIN–GROUP ELEMENTS: groups 1A–2A and 3A–8A. TRANSITION ELEMENTS: groups 3B–2B.

Period	1A (1)	2A (2)	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	8B (9)	8B (10)	1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (285)				

As of early 2002, elements 110–112 and 114 have not been named. Recently, element 116 was shown conclusively to exist.

INNER TRANSITION ELEMENTS

Period															
6	Lanthanides	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
7	Actinides	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (242)	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 (260)

END OF TEST

Answer Key

1. C
   Response:
   C = 2
2. A
   Response:
   A = 2
3. D
   Response:
   D = 2, E = 0.5
4. E
   Response:
   E = 2
5. E
   Response:
   E = 2
6. A
   Response:
   A = 2
7. C
   Response:
   C = 2
8. A
   Response:
   A = 2
9. C
   Response:
   C = 2
10. E
    Response:
    E = 2
11. E
    Response:
    E = 2
12. B
    Response:
    B = 2, E = 1
13. B
    Response:
    B = 2
14. C
    Response:
    C = 2
15. E
    Response:

E = 2, C = 1

16. E

Response:

E = 2, D = 1, A = 1

17. B

Response:

B = 2

18. D

Response:

D = 2

19. A

Response:

A = 2, C = 0.5

20. D

Response:

D = 2

21. C

Response:

C = 3, B = 1.5

22. D

Response:

D = 3, B = 2, C = 1, A = 1

23. E

Response:

E = 3, C = 2, D = 1

24. D

Response:

D = 3

25. C

Response:

C = 3 , B = 1.5, D = 1