Name: _____ Student number: _____

Chemistry 1A03 **Final Exam** **December 2013**

McMaster University

Instructors: D. Brock, G. Goward, J. Landry

Duration: 180 minutes

This test contains 20 numbered pages printed on both sides. There are **35** multiple-choice questions appearing on pages numbered 3 to 15. Pages 16 to 18 are extra space for rough work. Page 19 includes some useful data and equations, and there is a periodic table on page 20. 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 2 marks the total marks available are 70. 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 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 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.

Continued on next page

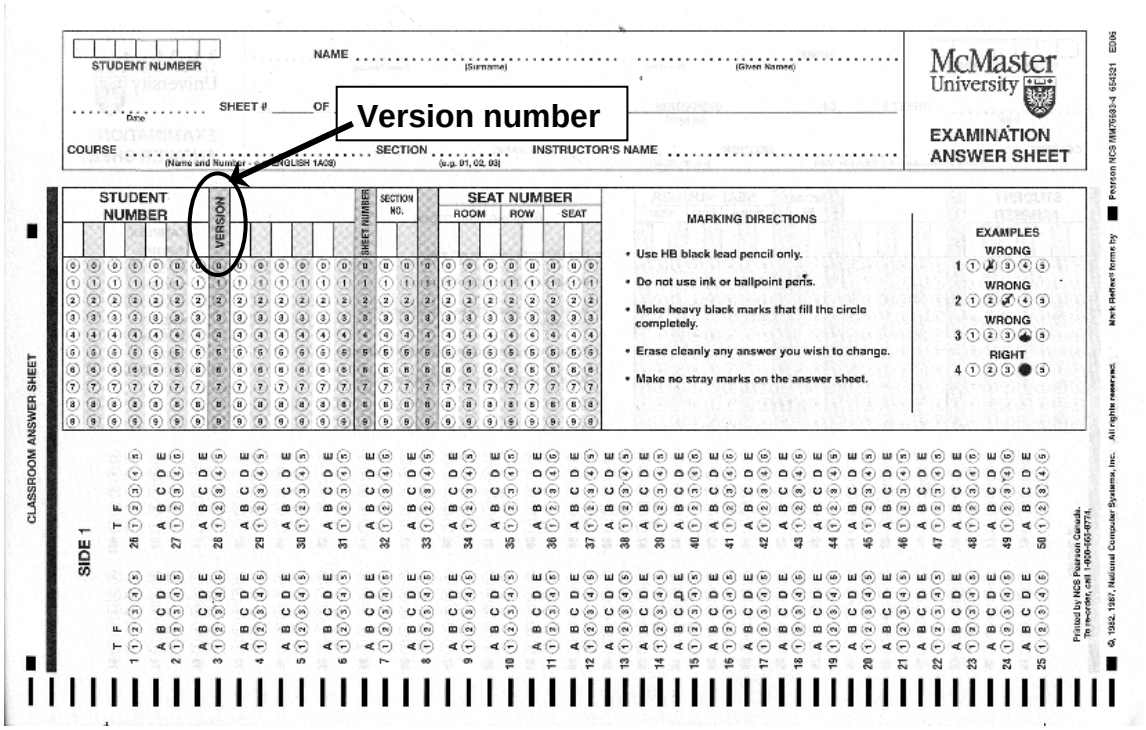
Name: _____ Student number: _____

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 <u>fill in the corresponding bubble numbers underneath</u>.
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".



 Continued on next page

Name: _____ Student number: _____

1. Which of the following molecules would have the **highest specific heat capacity**?

   A) Cu
   B) Al
   C) CH_4
   D) C_8H_{18}
   E) N_2

2. 0.50 mol of a gas is heated at constant pressure, so that its temperature increases from 21.00 ºC to 79.83 ºC. As a result, the gas expands from 10.0 L to 13.0 L against an external pressure of 0.965 atm. The heat capacity of the gas, at constant pressure, is 20.8 J mol^{-1} $^oC^{-1}$. What is the total energy change, **ΔU (in J) , for the gas?**

   A) +780
   B) −450
   C) –200
   D) +320
   E) +450

3. A 10.00 g piece of copper was heated to 1079 ^oC (specific heat capacity of copper is 0.385 J g^{-1} $^oC^{-1}$) and then placed into a beaker containing 8.00 mL of water at 25.0 ^oC. If some of the water is vaporized, how much would the **final contents of the beaker weigh (water + copper)**? $\Delta H^o_{vap}[H_2O]$ = 2.44 kJ g^{-1}; specific heat of capacity water is 4.184 J mol^{-1} $^oC^{-1}$; assume the density of water is 1.00 g mL^{-1}

   A) 15.83 g
   B) 12.42 g
   C) 17.48 g
   D) 10.96 g
   E) 13.47 g

Continued on next page

Name: _____ Student number: _____

4. Pentane (C_5H_{12}) undergoes combustion according to the following thermochemical equation:

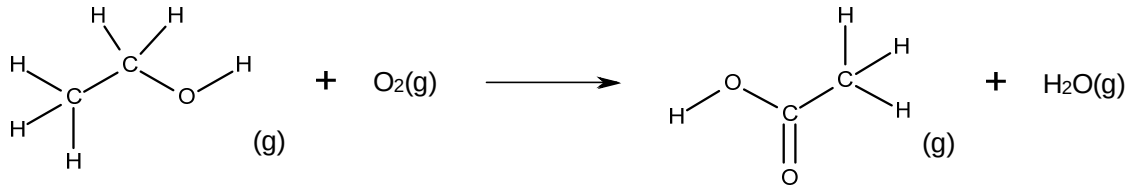
$$C_5H_{12}\,(l) + 8\,O_2\,(g) \rightarrow 5\,CO_2\,(g) + 6\,H_2O\,(l) \quad \Delta H°_{rxn} = -3509.0\ kJ$$

Given that: $\Delta H°_f\,[CO_2\,(g)] = -393.5\ kJ\ mol^{-1}$
$\Delta H°_f\,[H_2O\,(l)] = -285.8\ kJ\ mol^{-1}$

Calculate the **enthalpy of formation** of pentane, $\Delta H°_f$ in kJ mol^{-1}.

A) +420.4
B) −210.9
C) +551.2
D) −173.3
E) −420.4

5. Calculate **ΔH (in kJ mol^{-1})** using the appropriate bond enthalpy data (in kJ mol^{-1}) from those listed below for the reaction



O=O, 494; O-H, 464; C-O, 351; C=O, 803;
C≡O, 1075; C-H, 415; C-C, 347; O-O, 142

A) –39
B) –300
C) +3
D) –407
E) +763

Continued on next page

6. For a student completing a calorimetry experiment like that seen in Chemistry 1A03 (experiment # 5), which of the following is the **biggest source of non-preventable error**?

   A) Not allowing the solutions to cool down in the calorimeter before starting the reaction and taking data.
   B) A student's ability to use the pipette bulb.
   C) Not insulating the top of the calorimeter.
   D) Inaccuracies in the balances.
   E) Not putting enough ice in calorimeter.

7. Calculate the standard **enthalpy of formation**, ΔH_f° (in kJ mol^{-1}), of solid MgO, given the following data:

$$Mg(s) + O_2(g) + H_2(g) \rightarrow Mg(OH)_2(s) \qquad \Delta H^\circ_1 = -924.7 \text{ kJ}$$
$$Mg(OH)_2(s) \rightarrow MgO(s) + H_2O(l) \qquad \Delta H^\circ_2 = +37.1 \text{ kJ}$$
$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l) \qquad \Delta H^\circ_3 = -571.7 \text{ kJ}$$

   A) −601.8
   B) −426.3
   C) +601.8
   D) −2149.5
   E) +2149.5

8. For the process $He(g) \rightarrow He(l)$ at 4.2 K, which one of the following statements is **FALSE**?

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

 Continued on next page

9. Acid rain is produced through the reaction of sulfur dioxide with water to give an acidic solution. The reaction is

$$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq).$$

Use the thermochemical information given below to calculate the **standard Gibbs free energy** (in kJ) of the reaction at 298K.

	$H_2O(l)$	$SO_2(g)$	$H_2SO_3(aq)$
$\Delta H_f°$ / (kJ mol^{-1})	–285.83	–296.83	–627.98
S° / (J mol^{-1} K^{-1})	69.91	248.22	132.38

A) +10.03
B) –132.7
C) –10.03
D) +86.43
E) +132.7

10. Paraffin wax is an excellent material to store heat, having a specific heat capacity in the liquid phase of 2.9 J g^{-1} K^{-1} and a heat of fusion of 220 J g^{-1}; fusion occurs at 10 °C. In a home building material, a certain type of wax is infused in the drywall during manufacture so that it melts during the day, absorbing heat, and solidifies again at night, releasing the heat.

If the daytime temperature is 35.0 °C, and the evening temperature drops to exactly the phase change temperature for sufficient time that the phase change is complete, what is the **total amount of heat** delivered from 40.0 kg paraffin wax, and what is the **total entropy** change associated with the phase change?

A) 3.7×10^8 J, 8.2×10^3 J K^{-1}
B) 3.7×10^8 J, 2.7×10^4 J K^{-1}
C) 2.9×10^7 J, 1.5×10^2 J K^{-1}
D) 1.2×10^7 J, 4.9×10^4 J K^{-1}
E) 1.2×10^7 J, 3.1×10^4 J K^{-1}

 Continued on next page

11. Choose the **FALSE** statement regarding entropy.

A) The processes of melting and boiling are accompanied by positive changes of entropy of the substance.
B) Entropy is a property of state; its changes do not depend on the path taken by the system.
C) Entropy is an intensive property, in other words, it does not depend on the amount of substance present.
D) At T = 0 K, a perfect crystal has zero entropy.
E) A spontaneous process always implies an increase in the entropy of the universe.

12. Determine the **boiling point** of CS_2, **in °C**, from the following data:

	$CS_2(g)$	$CS_2(l)$
$\Delta H_f°$ / (kJ mol^{-1})	115.3	87.9
S° / (J mol^{-1} K^{-1})	237.8	151.0

A) 43
B) –14
C) 116
D) 258
E) 78

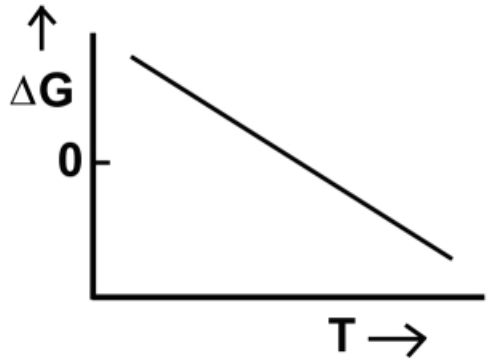
13. In which of the following processes does the **entropy of the system decrease**?

(i) $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$
(ii) $AgCl(s) \rightarrow Ag^+(aq) + Cl^-(aq)$
(iii) $A(g) + B(g) \rightarrow$ mixture of $A(g) + B(g)$
(iv) $C(graphite) \rightarrow C(diamond)$

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

 Continued on next page

14. The diagram below shows the variation of the Gibbs free energy with temperature, T, for some process. Identify the **FALSE** statement:



A) $\Delta H° = T\,\Delta S°$ at a certain temperature.
B) The process is spontaneous at high temperatures.
C) $\Delta S° > 0$ for this process.
D) If $\Delta H°$ remains constant, $\Delta S°$ must increase with T.
E) $\Delta H° > 0$ for this process.

15. For which of the following reactions would you **predict $\Delta H_{rxn}° < 0$ and $\Delta S_{rxn}° > 0$** ?

A) $O_3(g) \rightarrow O_2(g) + O(g)$
B) $5\ C(s) + 4\ KNO_3(s) \rightarrow 5\ CO_2(g) + 2\ N_2(g) + 2\ K_2O(s)$
C) $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$
D) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
E) $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

16. When $NH_3(g)$ reacts spontaneously with $HCl(g)$, $NH_4Cl(s)$ is formed. This is accompanied by the **following changes:**

A) $\Delta G < 0,\ \Delta H > 0,\ \Delta S < 0$
B) $\Delta G < 0,\ \Delta H > 0,\ \Delta S > 0$
C) $\Delta G < 0,\ \Delta H > 0,\ \Delta S > 0$
D) $\Delta G > 0,\ \Delta H < 0,\ \Delta S < 0$
E) $\Delta G < 0,\ \Delta H < 0,\ \Delta S < 0$

 Continued on next page

17. The interior and exterior of a nerve cell behave as a concentration cell. If the concentration of K^+ outside the cell is 0.045 M and the concentration inside is 0.45 M, what is the **potential difference** (in volts V) across the cell membrane? Assume normal body temperature, T = 37 °C and a one-electron transfer ($z = 1$).

A) 0.111
B) 0.0615
C) 0.583
D) 0.0167
E) 0.298

18. Given the following half reactions, calculate the **standard cell potential** (in V) for the spontaneous cell reaction.

$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^- \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$ $\quad E^o_{red} = +1.51$ V
$Pb^{2+}(aq) + 2\ e^- \rightarrow Pb(s)$ $\quad E^o_{red} = -0.13$ V

A) +2.37 V
B) –1.64 V
C) +1.38 V
D) –1.38 V
E) +1.64 V

19. Phosgene ($COCl_2$) is a poisonous gas that dissociates at high temperature into two other poisonous gases, carbon monoxide and chlorine. The equilibrium constant $K = 4.10 \times 10^{-3}$ at 600 K. Find the **equilibrium pressure of CO** after 0.124 atm of $COCl_2$ (g) is allowed to reach equilibrium at this temperature.

A) 0.0582
B) 0.1020
C) 0.0426
D) 0.0206
E) 0.0318

 Continued on next page

Name: _____ Student number: _____

20. Rank the species CO_2, CO, CO_3^{2-} and HCO_2^- (all atoms are bonded to C) in order of **increasing bond energy**, from lowest to highest, of the carbon-oxygen bonds.

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

21. You are asked to test the electrolyte performance of several aqueous solutions. Based on the trends of solubility and dissociation, rank the following solutions from **strongest to weakest electrolyte**:

1 M Na_2SO_4 (aq)
1 M HCOOH (aq) (Formic acid)
CH_3CH_2OH (l)
H_2O(l)
1 M HCl (aq)

A) $Na_2SO_4 > HCOOH > HCl > H_2O > CH_3CH_2OH$
B) $Na_2SO_4 > HCOOH > CH_3CH_2OH > H_2O > HCl$
C) $Na_2SO_4 > HCl > HCOOH > H_2O > CH_3CH_2OH$
D) $H_2O > CH_3CH_2OH > Na_2SO_4 > HCOOH > HCl$
E) $HCl > HCOOH > Na_2SO_4 > H_2O > CH_3CH_2OH$

22. A student is creating a concentration cell and needs to dilute a 0.020 M solution of Zn^{2+} to 0.0004 M solution. They are given a 1.00 mL pipette (measures only 1.00 mL accurately) and a 100.0 mL volumetric flask (measures only 100.0 mL accurately). **How would they accomplish this accurately**?

A) Add 2.00 mL of the 0.02 M solution and fill to 100.00 mL with water.
B) Add 2.00 mL of the 0.02 M solution and fill to 100.00 mL with water, then repeat with the new solution.
C) Add 1.00 mL of the 0.02 M solution and fill to 100.0 mL with water, then repeat with the new solution.
D) Add 1.00 mL of the 0.02 M solution and fill to 100.0 mL with water.
E) none of the above.

Continued on next page

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

A) $N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g)$
B) $Br_2(g) \rightleftharpoons 2\ Br(g)$
C) $2\ NO_2(g) + 7\ H_2(g) \rightleftharpoons 2\ NH_3(g) + 4\ H_2O(l)$
D) $2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$
E) $PC1_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

24. The molar solubility of $Ba(OH)_2$ is 0.108 M. If 2.0 g of solid $Ba(OH)_2$ is placed in a 150 mL vessel, **what volume** of a 0.25 M HCl solution would be required to bring the pH of the solution to 7?

A) 120 mL
B) 4.9 mL
C) 23 mL
D) 67 mL
E) 93 mL

25. Which of the following statements regarding atomic theory are **FALSE**?

(i) The energy of a photon is proportional to its frequency.
(ii) In a hydrogen atom, the electron is at a fixed distance from the nucleus.
(iii) As the velocity of a given particle gets larger, its wavelength gets shorter.
(iv) The size of atomic orbitals is mainly determined by the magnetic quantum number.
(v) For a given shell of a many-electron atom, d orbitals have higher energy than s orbitals.

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

 Continued on next page

26. Balance the following reaction under **acidic** conditions, and then choose the **FALSE** statement regarding the *balanced* spontaneous reaction.

$$MnO_4^-(aq) + SO_3^{2-}(aq) \rightarrow Mn^{2+}(aq) + SO_4^{2-}(aq)$$

A) MnO_4^- is the oxidizing agent.
B) The total number of electrons transferred in the balanced reaction is 8.
C) $$Q = \frac{[Mn^{2+}]^2[SO_4^{2-}]^5}{[MnO_4^-]^2[SO_3^{2-}]^5[H^+]^6}$$
D) In the balanced reaction, the coefficient of the sulfate ion is 5.
E) Mn^{2+} is a worse reducing agent than SO_3^{2-}.

27. Determine the **FALSE** statement.

A) HF is a stronger acid than HCl.
B) The conjugate acid of a hydride ion is hydrogen gas.
C) NH_3 has both a conjugate acid and a conjugate base.
D) The conjugate base of $H_2PO_4^-$ is HPO_4^{2-}.
E) $HClO_3$ is a stronger acid than $HClO_2$.

28. Determine the **strongest Lewis base** from the list below.

A) CH_3^-
B) H_2O
C) F^-
D) NH_3
E) HS^-

 Continued on next page

29. Which of the following statements is **FALSE** regarding a solution of 1.0 M HNO_3?

A) $K_b\ [NO_3^-] < 0$
B) $[H^+] > 10^{-7}\ M > [OH^-]$
C) $K_a\ [HNO_3] > 0$
D) pH = 0
E) $[H^+] = 1.0\ M$

30. What is the $\boldsymbol{pK_b}$ of the formate ion ($HCOO^-$) if a 2.5 M solution of formic acid (HCOOH) has a pH of 1.67?

A) 11.12
B) 9.44
C) 8.59
D) 4.56
E) 10.27

31. A solution of ethylamine ($CH_3CH_2NH_2$; $K_b = 4.30 \times 10^{-4}$) produces a pH = 12.67. What is the **% ionization** of the base?

A) 0.0015%
B) 0.91 %
C) 2.2 %
D) 1.5 %
E) 0.054 %

 Continued on next page

32. What is the **pH** of a 0.25 M solution of strontium hydroxide?

A) 12.79
B) 11.28
C) 13.70
D) 12.94
E) 12.54

33. If the pH of a solution is 12.100, what is the **concentration of OH^-** (mol L^{-1}) in the solution?

A) 0.106
B) 0.259
C) 0.0984
D) 0.0548
E) 0.0126

34. Determine the **FALSE** statement below.

A) H_2SeO_4 is a stronger acid than H_2TeO_3.
B) H_2CO_3 is not a strong acid
C) When dissolved in water, ClOH would produce a solution with pH > 7.
D) NaH is a strong base.
E) When dissolved in water, CH_3NH_2 will produce OH^-.

 Continued on next page

35. An organic acid (HA) has a molecular weight of 100. g mol^{-1}, a K_{ow} = 5.6 and a $K_a = 2.7 \times 10^{-2}$. If originally 2.0 g of the acid is dissolved in 100. mL of octanol (there is no dissociation in octanol), which is then placed in contact with 100. mL of water, what will be the **pH of the wate**r? (Consider the equilibrium processes to be sequential and unrelated chemically)

A) 1.48
B) 1.61
C) 1.74
D) 1.89
E) 2.01

Continued on next page

Name: _____ Student number: _____

Extra space for rough work:

Continued on next page

Name: _____ Student number: _____

Extra space for rough work:

Continued on next page

Name: _____ Student number: _____

Extra space for rough work:

Continued on next page

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
$R = 8.3145\ \text{J K}^{-1}\ \text{mol}^{-1} = 0.08206\ \text{L atm K}^{-1}\ \text{mol}^{-1}$
$c = 2.9979 \times 10^{8}\ \text{m/s}$
$m_e = 9.10 \times 10^{-31}\ \text{kg}$
Specific heat of water = 4.184 J / g·°C
$\Delta H^{\circ}_{vap}[H_2O] = 44.0\ \text{kJ mol}^{-1}$

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

1 atm = 101.325 kPa = 760 mm Hg
$1\ \text{J} = 1\ \text{kg m}^2\ \text{s}^{-2} = 1\ \text{kPa L} = 1\ \text{Pa m}^3$
$1\ \text{cm}^3 = 1\ \text{mL}$
1 Hz = 1 cycle/s

0°C = 273.15 K
$1\ \text{m} = 10^6\ \mu\text{m} = 10^9\ \text{nm} = 10^{10}\ \text{Å}$
$1\ \text{g} = 10^3\ \text{mg}$

De Broglie wavelength: $\lambda = \dfrac{h}{mu} = \dfrac{h}{p}$

Hydrogen atom energy levels:

$KE = \tfrac{1}{2}mu^2$

$E_n = \dfrac{-R_H}{n^2} = -2.179 \times 10^{-18}\ \text{J} / n^2$

Nernst Equation:

$$E = E^{\circ} - \frac{RT}{zF}\ln Q \quad = E^{\circ} - \frac{0.0257\ \text{V}}{z}\ln Q \quad = E^{\circ} - \frac{0.0592\ \text{V}}{z}\log_{10} Q$$

Entropy change: $\Delta S = \dfrac{q_{rev}}{T}$

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.

 Continued on next page

Name: ____________________ Student number: ______________

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