Name: _____ Student number: _____

Chemistry 1A03 **Final Exam** **Dec. 13, 2010**

McMaster University **VERSION 1**

Instructor: Drs. R. Dumont, G. Goward, J. Landry and P. Lock

Duration: 180 minutes

This test contains 28 numbered pages printed on both sides. There are **35** multiple-choice questions appearing on pages numbered 3 to 23. Pages 24, 25 and 26 are extra space for rough work. Page 27 includes some useful data and equations, and there is a periodic table on page 28. 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.

Questions 1 to 27 are each worth 2 marks and questions 28 – 35 are worth 3 marks each; the total marks available are 78. 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.

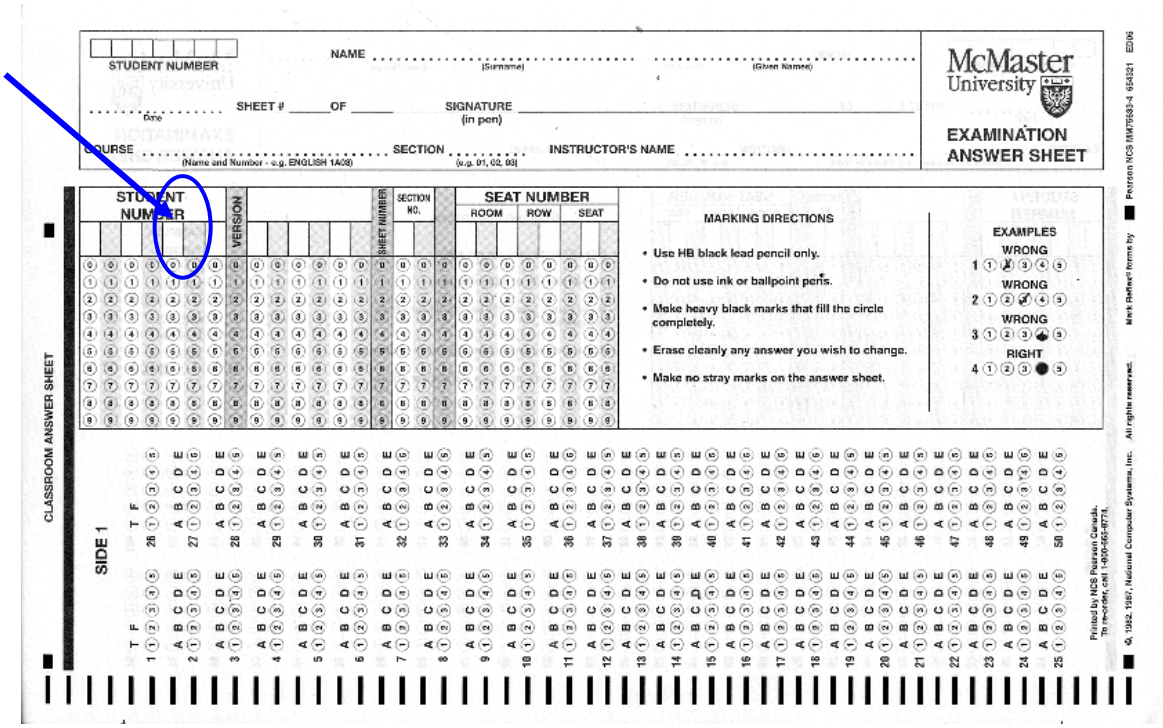
Name: _____ Student number: _____

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”.



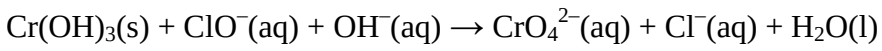
Name: _____ Student number: _____

Questions 1-27 are worth 2 marks each.

1. Which atomic property decreases **down** a group?
.
   A) the metallic character
   B) the first ionization energy
   C) the atomic radius
   D) the ionic radius
   E) the core charge

2. Which **ONE** of the following pairs of reagents produces **no visible change** when they are mixed together?
.
   A) Cu(s) + HCl(aq)
   B) KCl(aq) + $AgClO_4$(aq)
   C) Zn(s) + HCl(aq)
   D) NaOH(aq) + phenolphthalein
   E) Cu(s) + HNO_3(aq)

3. **Balance** the following redox reaction in **basic** solution. Use the smallest whole number coefficients.



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

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

.

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

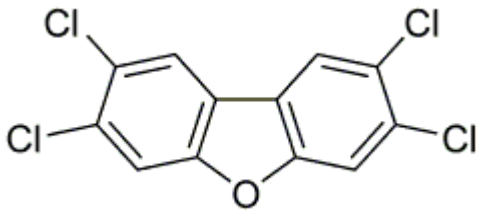
4. Which **one** species contains the greatest number of **protons**?

.

A) P^-
B) Cl^-
C) S^{2+}
D) Si^-
E) F^-

5. The octanol-water partition coefficient of tetrachlorodibenzofuran (TCDF) is $K_{ow} = 3.16\times10^{7}$.

TCDF(aq) ⇄ TCDF(org)



With regard to this persistent organic pollutant (POP), choose the **one FALSE** statement.

.

A) Adverse health effects of long term exposure to POPs such as TCDF is a public health concern.
B) The molecule is highly lipophilic, and therefore accumulates in fat tissue.
C) The log K_{ow} = 7.500
D) The electron affinity of the chlorine atoms makes the molecule detectable by electron capture detection.
E) The equilibrium lies far to the left due to the high hydrophilicity of the molecule.

6. Using an ice calorimeter such as that in experiment # 5, it was determined that the reaction of 0.14 g of zinc with excess HCl (aq), caused 0.68 g of ice to melt. What was the heat of reaction per mole of Zn (kJ mol^{-1})? [ΔH_{fus}(ice) = 333 J g^{-1}]

.

A) –180
B) –95
C) –110
D) 240
E) 590

7. For which of the following processes is work done **by** the system **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) $N_2(g) + 2\ H_2O(1) \rightarrow N_2H_4(l) + O_2(g)$
   .
   A) i, iv
   B) i, ii
   C) iv, v
   D) ii, iii
   E) iii, v

8. How much heat (in kJ) is required to convert 36.0 g of liquid H_2O at 50 °C to gaseous H_2O at 100 °C? $\Delta H_{vaporization}$ for H_2O (l) = 44.0 kJ/mol. The specific heat of liquid H_2O is 4.184 J K^{-1} g^{-1}.
   .
   A) 84.0
   B) 8.56
   C) 7.12×10^3
   D) 67.8
   E) 95.5

9. At 1000 K, initially pure $NO_2(g)$ decomposes according to

$$2\ NO_2(g) \rightleftharpoons 2\ NO(g) + O_2(g)$$

with an equilibrium constant, $K_p = 158$, when pressures are expressed in atm. At equilibrium, the partial pressure of $O_2 = 0.25$ atm. What are the **partial pressures** (in atm) of **NO(g)** and **NO_2(g)** (in that order) at equilibrium at 1000 K?

.

A) $0.250, 2.0\times10^{-2}$
B) $0.50, 4.0\times10^{-2}$
C) $0.125, 2.0\times10^{-2}$
D) $0.50, 2.0\times10^{-2}$
E) $0.125, 4.0\times10^{-4}$

10. The reaction,

$$Ca(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

is carried out in a constant pressure calorimeter with heat capacity, C (J/K). The temperature was observed to increase. For this experiment, which **ONE** of the following statements is **FALSE**?

.

A) $\Delta H = -C\Delta T$
B) $\Delta H < \Delta U$
C) Work is done by the system.
D) $\Delta H \neq \Delta U$
E) This reaction is exothermic.

11. $PCl_5(s)$ can be prepared by the reaction $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$. Calculate the enthalpy change (in kJ) that accompanies the production of 100.0 g of $PCl_5(s)$ by the above reaction, given the following data.

$P_4(s) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(l)$ $\Delta H^o = -1280$ kJ

$P_4(s) + 10\ Cl_2(g) \rightarrow 4\ PCl_5(s)$ $\Delta H^o = -1774$ kJ

.

A) +79.1
B) –238
C) –59.3
D) –114
E) +164

12. Which **one** of the following statements is **FALSE**?

.

A) For constant pressure processes, the enthalpy change of a system (ΔH_{sys}) is different from its energy change (ΔU_{sys}) by the amount $P\Delta V$.
B) Enthalpy is a state function.
C) Work flow out of a system is considered positive when calculating ΔU_{sys}.
D) Heat flow into a system increases the energy of the system.
E) When neither energy nor mass can enter or escape a system, it is said to be isolated.

13. When a particular gas expands against a constant external pressure of 1.00 atm, it does 5 J of work done on the surroundings. During this transformation the gas also absorbs 10 J of heat. What is the **energy change**, ΔU (in J), for the gas?

    .

    A) 0
    B) -15
    C) +15
    D) -5
    E) +5

14. Predict the **approximate pH** of a solution formed when sodium formate (HCOONa) is dissolved in water.
    K_a (HCOOH) = 1.8×10^{-4}

    .

    A) Neutral
    B) Weakly Acidic
    C) Strongly Acidic
    D) Weakly Basic
    E) Strongly Basic

15. Which of the following statements is **TRUE** regarding the acids $HClO_3$ and $HClO_2$?
(i) $HClO_3$ is a stronger acid than $HClO_2$.
(ii) There are six nonbonding electron pairs in the charge-minimized Lewis structure of $HClO_2$.
(iii) The conjugate base of $HClO_3$ has three equivalent resonance structures.
(iv) The average formal charge on O in the conjugate base of $HClO_2$ is –1.
.
A) i, ii, iii
B) iii, iv
C) ii, iii, iv
D) ii, iv
E) i, iii

16. Consider all of the following molecules to act as Brønsted acids. Which one would have the **strongest conjugate base**?
.
A) NH_3
B) H_2O
C) HF
D) HCl
E) CH_4

17. In the reaction of hydrofluoric acid with water to produce hydronium ion and fluoride, **water** is acting as?

i) Arrhenius Base
ii) Brønsted Acid
iii) Lewis Base
iv) Brønsted Base
v) Lewis Acid
vi) Arrhenius Acid

.

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

18. What is the **pH** of a 0.0342 M solution of HCl?

.

A) 3.492
B) 1.081
C) 1.466
D) 4.456
E) 7.568

19. Which **one** of the following statements is **TRUE** for a 0.1 M aqueous solution of a weak monoprotic acid?

.

A) $[OH^-] > [H^+]$
B) pH = 1
C) pH > 1
D) $[H^+] < [A^-]$
E) pH < 1

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

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

(ii) $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

(iii) $O_3(g) \rightarrow O_2(g) + O(g)$

(iv) $5\,C(s) + 4\,KNO_3(s) \rightarrow 5\,CO_2(g) + 2\,N_2(g) + 2\,K_2O(s)$

.

A) ii
B) iv
C) iii
D) i
E) none

21. You are provided with four 0.035 M metal solutions (list below) and analytical glassware for diluting samples. You are required to create an electrochemical cell that will produce a potential of 0.814 V. Which metal combination would be the best to start with?

$Au^{3+} + 3e^- \rightarrow Au\ (s)$; $E°_{red} = 1.52$ V
$Ag^+ + e^- \rightarrow Ag\ (s)$; $E°_{red} = 0.800$ V
$Cd^{2+} + 2e^- \rightarrow Cd\ (s)$; $E°_{red} = -0.403$ V
$Mn^{2+} + 2e^- \rightarrow Mn\ (s)$; $E°_{red} = -1.18$ V

.

A) Ag^+/Ag^+
B) Cd^{2+}/Au^{3+}
C) Mn^{2+}/Cd^{2+}
D) Cd^{2+}/Ag^+
E) Mn^{2+}/Au^{3+}

22. What is the value of $\Delta G°$ (in kJ) at 298K for $4\ Cl_2(g) + CH_4(g) \rightarrow CCl_4(l) + 4\ HCl(g)$? Use the following $\Delta G_f°$ data at 298K:

$\Delta G_f°(CH_4(g)) = -50.8$ kJ/mol
$\Delta G_f°(CCl_4(l)) = -65.3$ kJ/mol
$\Delta G_f°(HCl(g)) = -95.3$ kJ/mol

.

A) –260.8
B) –433.6
C) –371.9
D) –395.7
E) +290.3

23. 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 combination reaction at 298K.

Data:

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

.

A) +129
B) +10.0
C) –254
D) +55.3
E) –162

24. The reaction,

$$2\ SO_3(g) \rightarrow 2\ SO_2(g) + O_2(g)$$

carried out at 298K, where ΔH = 198 kJ, will

.

A) be spontaneous only in the reverse direction
B) be spontaneous at any temperature
C) not be spontaneous at any temperature
D) be spontaneous only at low temperature
E) be spontaneous only at high temperature

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

.

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

26. Calculate the **boiling point** (in °C) of bromine given the following data:

$\Delta H_f°[Br_2(g)] = 30.907 \text{ kJ mol}^{-1}$
$S°[Br_2(l)] = 152.2 \text{ J K}^{-1} \text{ mol}^{-1}$
$S°[Br_2(g)] = 245.463 \text{ J K}^{-1} \text{ mol}^{-1}$

.

A) 19
B) 311
C) 123
D) 4
E) 58

27. The interior and exterior of a nerve cell behave as a concentration cell. If the concentration of K^+ outside the cell is 0.030 M and the concentration inside is 0.30 M, what is the **potential difference** across the cell membrane, in volts V? Assume normal body temperature, T = 37°C and a one-electron transfer (z = 1).

.

A) 0.00517
B) 0.132
C) 0.0267
D) 0.0615
E) 0.198

Questions 28-35 are worth 3 marks each.

28. The standard enthalpies of formation of $SO_3(g)$, S(g) and O(g) are –359.7, +278.8 and +249.0 kJ mol^{-1}, respectively. Use these data to calculate the **average bond energy** (in kJ mol^{-1}) of the **S=O** double bond.

    .

    A) +277.9
    B) +461.8
    C) –277.9
    D) –461.8
    E) +307.8

29. Which of the following statements is(are) **FALSE**? Be sure to minimize formal charges.

(i) IBr_3 is T-shaped.
(ii) The iodine atom in IBr_3 carries two nonbonded electrons pairs.
(iii) The average bond order in SO_3^{2-} is 5/3.
(iv) SO_3^{2-} is triangular pyramidal.
(v) The formal charge on S in SO_3^{2-} is +1.

.

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

30. A 1.0 M solution of HCN(aq) has a pH of 4.60. What is the K_b of CN^-?
.

A) 3.4×10^{-6}
B) 2.9×10^{-6}
C) 9.1×10^{-5}
D) 1.6×10^{-5}
E) 7.3×10^{-4}

31. Consider a standard electrochemical cell built from the two half-cells below and identify the **TRUE** statement(s).

$Cr^{3+}(aq) + 3\ e^- \rightarrow Cr(s)$ $\quad E°_{red} = -0.740$ V

$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^- \rightarrow NO(g) + 2\ H_2O(l)$ $\quad E°_{red} = +0.956$ V

(i) The spontaneous cell reaction is

$Cr^{3+}(aq) + NO(g) + 2\ H_2O(l) \rightarrow Cr(s) + NO_3^-(aq) + 4\ H^+(aq)$.

(ii) A schematic cell diagram could be $Cr(s) \mid Cr^{3+}(aq) \parallel HNO_3(aq) \mid NO(g) \mid Pt(s)$.

(iii) The standard cell potential $E°_{cell} = +0.216$ V.

(iv) Nitrate ions are reduced at the cathode.

(v) $\Delta G°$ for the spontaneous cell reaction (with the smallest integer stoichiometric coefficients) is –490.9 kJ.

.

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

32. Calculate the standard **entropy change of the universe,** ΔS_{univ}° (in J K^{-1}), at 25.00°C for

$$CO(g) + 2\,H_2(g) \rightarrow CH_3OH(l)$$

from the following data:

	ΔH_f° (kJ mol^{-1})	S° (J K^{-1} mol^{-1})
$H_2(g)$	0	130.684
CO(g)	–110.525	197.674
$CH_3OH(l)$	–238.66	126.8

.

A) +818.8
B) +97.52
C) +1121
D) –312.2
E) +423.8

33. The maximum wavelength of light sufficient to break a Cl-Cl bond is 489 nm. Given this information, and the data below, determine the **bond energy** (kJ mol^{-1}) for the H-Cl bond.

    BE(H-H) = 436 kJ mol^{-1}
    $\Delta H_f°$(HCl, (g)) = –92.31 kJ mol^{-1}

    .

A) 386
B) –433
C) –386
D) 433
E) 288

34. A 1.25 L vessel contains 1.00 L of HF(g) at 3.00 atm and 250. mL of an HF(aq) solution at 298K. 23.5% of the total HF in the vessel is in the aqueous solution. What is the **pH** of the solution? K_a (HF) = 6.6×10^{-4}

    .

    A) 2.75
    B) 2.50
    C) 1.75
    D) 2.25
    E) 2.00

35. The K_{sp} value for $SrSO_4$ is 7.6×10^{-7}, and the K_{sp} value for SrF_2 is 7.9×10^{-10}. $Sr(NO_3)_2(s)$ is added to 1.00 L of solution containing 0.020 mol F^- and 0.10 mol of SO_4^{2-} with constant volume.

Which salt **precipitates first**, and what is the **$[Sr^{2+}]$** in solution when the precipitate forms?

.

A) $SrSO_4$ precipitates first, when $[Sr^{2+}] = 5.3\times10^{-9}$ M
B) SrF_2 precipitates first, when $[Sr^{2+}] = 2.0\times10^{-6}$ M
C) SrF_2 precipitates first, when $[Sr^{2+}] = 1.6\times10^{-7}$ M
D) SrF_2 and $SrSO_4$ precipitate together when $[Sr^{2+}] = 3.8\times10^{-4}$ M
E) $SrSO_4$ precipitates first, when $[Sr^{2+}] = 7.7\times10^{-8}$ M

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Extra space for rough work:

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 × 10^{8} m/s
m_e = 9.10 × 10^{-31} kg
Specific heat of water = 4.184 J / g·°C
$\Delta H^{o}_{vap}[H_2O]$ = 44.0 kJ mol^{-1}

F = 96485 C/mol
N_A = 6.022 × 10^{23} mol^{-1}
h = 6.6256 × 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:

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

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

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

ALDRICH®

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
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]												

(Groups 3–12: Transition Metals)

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