

Name: _____

Student number: _____

Chemistry 1E03

Deferred Exam

February 2014

McMaster University

VERSION 1

Instructors: Drs. R.S. Dumont, A.P. Hitchcock & J.C. Landry

Duration: 180 minutes

This test contains 23 numbered pages printed on both sides. There are **35** multiple-choice questions appearing on pages numbered 3 to 18. Pages 19, 20 and 21 provide extra space for rough work. Page 22 includes some useful data and equations, and there is a periodic table on page 23. 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 2 marks; the total marks available are 70. 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 HB 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: _____

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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, *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".

CLASSROOM ANSWER SHEET

McMaster University
EXAMINATION ANSWER SHEET

STUDENT NUMBER: _____ NAME: _____ (Surname) _____ (Given Name) _____
SHEET # _____ OF _____ SIGNATURE (in pen) _____
COURSE (Name and Number - e.g. ENGLISH 1A06) _____ SECTION (e.g. 01, 02, 03) _____ INSTRUCTOR'S NAME _____

STUDENT NUMBER _____ **VERSION** _____

SEAT NUMBER
ROOM _____ ROW _____ SEAT _____

MARKING DIRECTIONS

- Use HB black lead pencil only.
- Do not use ink or ballpoint pens.
- Make heavy black marks that fill the circle completely.
- Erase cleanly any answer you wish to change.
- Make no stray marks on the answer sheet.

EXAMPLES

WRONG
1 ① ② ③ ④ ⑤
WRONG
2 ① ② ③ ④ ⑤
WRONG
3 ① ② ③ ④ ⑤
RIGHT
4 ① ② ③ ● ④ ⑤

SIDE 1

1 T F 2 A B C D E 3 A B C D E 4 A B C D E 5 A B C D E 6 A B C D E 7 A B C D E 8 A B C D E 9 A B C D E 10 A B C D E 11 A B C D E 12 A B C D E 13 A B C D E 14 A B C D E 15 A B C D E 16 A B C D E 17 A B C D E 18 A B C D E 19 A B C D E 20 A B C D E 21 A B C D E 22 A B C D E 23 A B C D E 24 A B C D E 25 A B C D E

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Name: _____

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

.

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

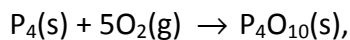
2. An element is a molecular solid at room temperature. It burns to form a solid oxide, which is acidic when dissolved in water. The element's first ionization energy is higher than either of its neighboring elements (to the left and right) in the periodic table.

Which element is this?

.

- A) S
- B) P
- C) Cl
- D) Si
- E) Al

3. In the combustion of phosphorus,



30.12 kJ of heat is lost from the system, while the volume of gas in the system decreases from 2.00 L to 0.78 L at a constant pressure of 1.00 atm. Assuming this volume change is the only source of work, calculate the resulting **energy change** (in kJ) for the chemical system.

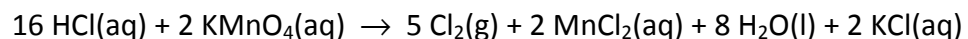
.

- A) -153.74
- B) +123.6
- C) -30.00
- D) +93.50
- E) -30.24

Name: _____

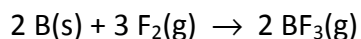
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4. Identify the **oxidizing agent** in the following reaction.



- .
- A) $\text{MnCl}_2\text{(aq)}$
 - B) $\text{H}^+\text{(aq)}$
 - C) $\text{Cl}^-\text{(aq)}$
 - D) $\text{K}^+\text{(aq)}$
 - E) $\text{MnO}_4^-\text{(aq)}$

5. Considering the reaction



and the data below, identify the **FALSE** statement(s).

enthalpy of formation of $\text{B(g)} = 563 \text{ kJ mol}^{-1}$

bond enthalpy of F-F bond = 159 kJ mol^{-1}

bond enthalpy of B-F bond = 646 kJ mol^{-1}

- (i) The reaction is a redox reaction.
- (ii) The reaction of boron and fluorine is endothermic.
- (iii) The sublimation of boron is an endothermic process.
- (iv) $\text{F}_2\text{(g)}$ is a highly reactive species.

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

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6. Which of the following electron configurations are **excited states** of an element in group 4A?

(i) $1s^2 2s^2 2p^2$ (ii) $1s^2 2s^2 2p^3$ (iii) $1s^2 2s^1 2p^3$ (iv) $1s^2 2s^1 2p^5$ (v) $1s^2 2s^1 2p^2 3d^1$

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

7. Identify the **TRUE** statement(s) among the following:

- (i) The breaking of a chemical bond is always endothermic.
(ii) The thermite reaction $\text{Fe}_2\text{O}_3(\text{s}) + 2 \text{Al}(\text{s}) \rightarrow 2 \text{Fe}(\text{l}) + \text{Al}_2\text{O}_3(\text{s})$ is endothermic.
(iii) The enthalpy change for $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{graphite}) + 2 \text{H}_2(\text{g})$ equals 4 times the C-H bond energy.
(iv) For any compound $\Delta H_f^\circ(\text{solid}) < \Delta H_f^\circ(\text{liquid})$.

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

Name: _____

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8. Which of the following statements are **TRUE**?

- (i) Alkali metal hydrides produce $\text{H}_2(\text{g})$ upon reacting with water.
- (ii) Redox reactions between alkali metals (Group 1A) and halogens (Group 7A) produce ionic compounds which are soluble in water.
- (iii) $\text{HF}(\text{aq})$ is a stronger acid than $\text{HCl}(\text{aq})$.
- (iv) Mixing saturated aqueous solutions of phosphoric acid and calcium hydroxide produces no visible reaction.

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

9. Which of the following molecules are **polar**?

- (i) PF_5 (ii) SF_4 (iii) CO_2 (iv) SO_2 (v) H_2SO_4

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

Name: _____

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10. Which **one** of the following describes the **shape** of BrF_5 ?

- .
- A) octahedral
- B) see-saw
- C) trigonal bipyramidal
- D) square planar
- E) square-based pyramidal

11. For the Lewis structure of ClNO_2 , where nitrogen is the central atom and the other atoms are terminal, choose the **TRUE** statements.

- (i) N has 4 bonding electron pairs.
- (ii) N has 3 bonding electron pairs and 1 lone electron pair.
- (iii) N has a formal charge of +1.
- (iv) N has a formal charge of 0.
- (v) There are 3 resonance forms.

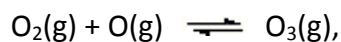
- .
- A) i and iii
- B) v
- C) ii, iv and v
- D) ii and iii
- E) i, iii and v

12. Which of **one** the following species has the **most negative average formal charge** on the oxygen atoms?

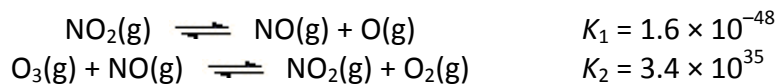
.

- A) ClO_3^-
- B) SeO_3^{2-}
- C) PO_4^{3-}
- D) SeO_4^{2-}
- E) SO_2

13. Determine the **equilibrium constant** for the formation of ozone at 298 K,



from the following data at 298 K:



.

- A) 3.4×10^{-23}
- B) 5.6×10^{53}
- C) 1.8×10^{12}
- D) 5.4×10^{-13}
- E) 2.9×10^{22}

14. Arrange the following substances in order of **increasing** molar **entropy** at 25°C:
 $\text{Ne}(\text{g})$, $\text{SO}_2(\text{g})$, $\text{Na}(\text{s})$, and $\text{H}_2\text{O}(\text{l})$

.

- A) $\text{Ne}(\text{g}) < \text{Na}(\text{s}) < \text{H}_2\text{O}(\text{l}) < \text{SO}_2(\text{g})$
- B) $\text{Ne}(\text{g}) < \text{Na}(\text{s}) < \text{SO}_2(\text{g}) < \text{H}_2\text{O}(\text{l})$
- C) $\text{Na}(\text{s}) < \text{H}_2\text{O}(\text{l}) < \text{Ne}(\text{g}) < \text{SO}_2(\text{g})$
- D) $\text{Na}(\text{s}) < \text{H}_2\text{O}(\text{l}) < \text{SO}_2(\text{g}) < \text{Ne}(\text{g})$
- E) $\text{H}_2\text{O}(\text{l}) < \text{SO}_2(\text{g}) < \text{Na}(\text{s}) < \text{Ne}(\text{g})$

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15. A certain reaction has $\Delta H = +51.7 \text{ kJ}$, and $\Delta S = -105 \text{ J K}^{-1}$. **For what temperature(s) is the reaction spontaneous?**

.

- A) above 219°C
- B) all temperatures
- C) below 219°C
- D) at 219°C only
- E) no temperature

16. The standard elemental form of mercury at 300. K is Hg(l) . The standard enthalpy of formation for Hg(g) is $+60.78 \text{ kJ mol}^{-1}$. The standard entropy of vaporization of mercury is $+97.3 \text{ J K}^{-1} \text{ mol}^{-1}$. Calculate the equilibrium **vapour pressure** (in atm) of mercury at **300. K**. Hint: write an expression for the equilibrium constant.

.

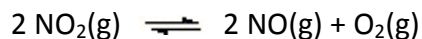
- A) 3.16×10^{-6}
- B) 0.277
- C) 2.59×10^{-5}
- D) 0.924
- E) 12.7

17. Which of the following statement(s) is(are) **TRUE**?

- (i) Gibbs free energy, ΔG , of a reaction varies with temperature.
- (ii) A reaction with negative ΔH , and negative ΔS , is spontaneous at sufficiently high temperature.
- (iii) If the equilibrium constant of a reaction is greater than one, the reaction is spontaneous under standard conditions.

- .
A) ii, iii
B) i
C) ii
D) i, ii
E) i, iii

18. At 1000 K, initially pure $\text{NO}_2(\text{g})$ decomposes according to



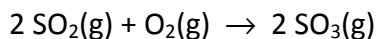
with an equilibrium constant, $K_p = 158$. At equilibrium, the partial pressure of O_2 is 0.250 atm. What are the **partial pressures (in atm) of $\text{NO}(\text{g})$ and $\text{NO}_2(\text{g})$** (in that order) at equilibrium, at 1000 K?

- .
A) 0.250, 1.99×10^{-2}
B) 0.125, 1.99×10^{-2}
C) 0.500, 1.99×10^{-2}
D) 0.500, 3.98×10^{-4}
E) 0.125, 3.98×10^{-4}

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19. What is ΔG° (in kJ mol^{-1}) for

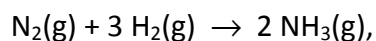


at 700 K, under standard conditions of 1 atm partial pressure for all gases, given that $K_p = 3.0 \times 10^4$ at 700 K?

.

- A) +60
- B) -26
- C) 0.0
- D) +26
- E) -60

20. For the reaction,



$\Delta G^\circ = -33.2 \text{ kJ mol}^{-1}$ at 25°C . In a certain experiment at 25°C , the initial partial pressures are $P(\text{H}_2) = 0.100 \text{ atm}$, $P(\text{N}_2) = 0.200 \text{ atm}$, and $P(\text{NH}_3) = 20.0 \text{ atm}$. What is the initial ΔG (in kJ mol^{-1}) for the reaction under **these conditions**?

.

- A) +33.2
- B) -5.7
- C) -33.2
- D) -9.9
- E) +2.8

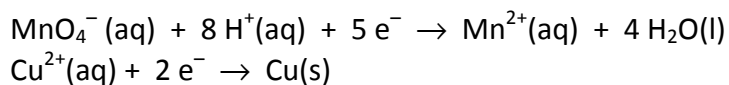
Name: _____

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21. The melting point of tungsten, 3407°C, is the second highest among the elements. Only that of carbon is higher. The enthalpy of fusion (i.e., enthalpy of melting) of tungsten is 35.2 kJ mol⁻¹. What is the **entropy of fusion (in J mol⁻¹ K⁻¹)** of tungsten?

- .
A) +10.3
B) +104
C) -10.3
D) -9.56
E) +9.56

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

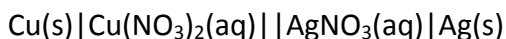


$$E_{\text{red}}^{\circ} = +1.51 \text{ V}$$

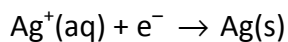
$$E_{\text{red}}^{\circ} = +0.34 \text{ V}$$

- .
A) -1.17 V
B) -1.85 V
C) +1.85 V
D) +1.32 V
E) +1.17 V

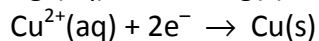
23. Select the **TRUE** statement(s) for the following electrochemical cell:



Data:



$$E^\circ_{\text{red}} = +0.80 \text{ V}$$

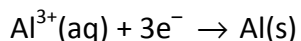


$$E^\circ_{\text{red}} = +0.34 \text{ V}$$

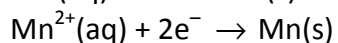
- (i) The concentration of Ag^+ increases in the solution containing the Ag electrode.
- (ii) Electrons flow in the external circuit from the Cu to the Ag electrode.
- (iii) Ag metal is a stronger reducing agent than Cu metal.
- (iv) The Cu electrode is the cathode of the electrochemical cell.
- (v) Nitrate anions migrate to the Cu electrode through the salt bridge.

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

24. Find the one **FALSE** statement about the electrochemical cell based on the two reduction half-reactions shown below. The concentrations of the ions are $[\text{Al}^{3+}] = 0.010 \text{ M}$, $[\text{Mn}^{2+}] = 0.100 \text{ M}$.



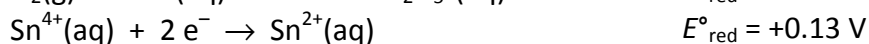
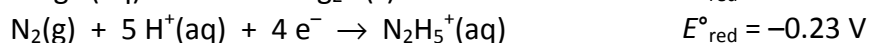
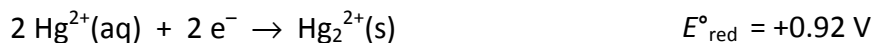
$$E^\circ_{\text{red}} = -1.66 \text{ V}$$



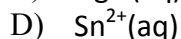
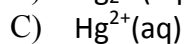
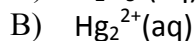
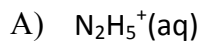
$$E^\circ_{\text{red}} = -1.18 \text{ V}$$

- .
A) The observed cell potential is 0.49 V.
B) Al(s) is a stronger reducing agent than Mn(s).
C) The cell diagram is
 $\text{Al(s)} | \text{Al}^{3+}\text{(aq, 0.010 M)} || \text{Mn}^{2+}\text{(aq, 0.100 M)} | \text{Mn(s)}$.
D) For the cell balanced equation, $Q = [\text{Al}^{3+}] / [\text{Mn}^{2+}]$.
E) Six electrons are transferred in the balanced cell reaction.

25. Given the following half-reactions, identify the **best reducing agent**.



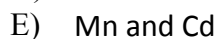
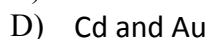
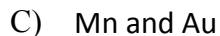
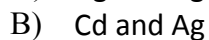
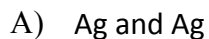
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26. You are provided with four 0.035 M metal solutions (listed below) and analytical glassware for diluting samples. You are required to create an electrochemical cell that will produce a potential of +0.814 V. Which **combination of metals** would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



.



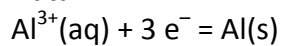
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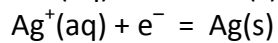
27. What is the **potential, in volts**, of the following electrochemical cell?



Data:



$$E^{\circ}_{\text{red}} = -1.66 \text{ V}$$



$$E^{\circ}_{\text{red}} = +0.80 \text{ V}$$

.

A) 2.52

B) 2.34

C) 2.40

D) 2.58

E) 2.46

28. What is the **pOH** of a 100. mL solution of 0.00059 M HNO_3 ?

.

A) 10.77

B) 7.00

C) 3.23

D) 4.23

E) 9.77

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29. Heroin, a derivative of morphine, is a powerful analgesic and a powerful narcotic agent. **Calculate K_b** for heroin if the pH of a 1.7×10^{-3} M solution was found to be 9.60.

- .
A) 3.7×10^{-7}
B) 9.5×10^{-7}
C) 8.3×10^{-7}
D) 1.5×10^{-7}
E) 2.3×10^{-2}

30. For the six substances listed below, identify how many will form **acidic, neutral or basic solutions** (in that order) when each substance is dissolved in water.

Ba(OH)₂ SO₃ HOCl Li₂O CaBr₂ HF

- .
A) 3 1 2
B) 2 2 2
C) 1 2 3
D) 3 0 3
E) 2 1 3

31. What is the **pH** of a monochloroacetic acid (CH₂ClCOOH) solution that is 5.00 % dissociated? $K_a = 1.35 \times 10^{-3}$

- .
A) 4.17
B) 0.29
C) 2.87
D) 1.30
E) 1.59

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Student number: _____

32. Your stomach (volume = 2.5 L) has a pH of 1.00 because of the presence of HCl. **How many grams of $\text{Mg}(\text{OH})_2$** (58.3 g mol^{-1}) do you need to add to completely neutralize the acid in your stomach?

.

- A) 15 g
- B) 2.9 g
- C) 21 g
- D) 7.3 g
- E) 5.8 g

33. A 2.60 g sample of propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$, molar mass = 74.1 g mol^{-1} , $K_a = 1.40 \times 10^{-5}$) was dissolved in water and made up to a final volume of 100. mL in water. **What is the pH** of this solution?

.

- A) 3.26
- B) 2.66
- C) 4.85
- D) 2.32
- E) 1.82

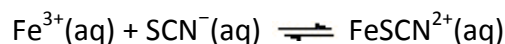
34. Order the following species according to **increasing acid dissociation constant, K_a** :

CH_3COOH , CF_3COOH , CH_2FCOOH , $\text{CH}_3\text{CH}_2\text{OH}$

.

- A) $\text{CH}_3\text{COOH} < \text{CF}_3\text{COOH} < \text{CH}_2\text{FCOOH} < \text{CH}_3\text{CH}_2\text{OH}$
- B) $\text{CF}_3\text{COOH} < \text{CH}_2\text{FCOOH} < \text{CH}_3\text{CH}_2\text{OH} < \text{CH}_3\text{COOH}$
- C) $\text{CH}_3\text{CH}_2\text{OH} < \text{CF}_3\text{COOH} < \text{CH}_2\text{FCOOH} < \text{CH}_3\text{COOH}$
- D) $\text{CH}_3\text{COOH} < \text{CH}_2\text{FCOOH} < \text{CF}_3\text{COOH} < \text{CH}_3\text{CH}_2\text{OH}$
- E) $\text{CH}_3\text{CH}_2\text{OH} < \text{CH}_3\text{COOH} < \text{CH}_2\text{FCOOH} < \text{CF}_3\text{COOH}$

35. In the experiment "Determination of an Equilibrium Constant for a Chemical Reaction" a calibration curve is generated to relate absorbance to $[\text{FeSCN}^{2+}]$. In preparing the calibration curve, $[\text{FeSCN}^{2+}]$ is assumed to be equal to $[\text{SCN}^-]_{\text{initial}}$, since $[\text{Fe}^{3+}]_{\text{initial}}$ is much greater than $[\text{SCN}^-]_{\text{initial}}$ for the calibration curve portion of the experiment. The equilibrium constant, K , for this reaction is 125. If 49 ml of 0.200 M Fe^{3+} is mixed with 1.0 ml of 0.00200 M SCN^- , what is the **percent error in $[\text{FeSCN}^{2+}]_{\text{equilibrium}}$** that results from this approximation?



.

- A) 1.9%
- B) 4.1%
- C) 2.6%
- D) 0.22%
- E) 11%

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Some general data/formulas are provided on this page.**A Periodic Table with atomic weights is provided on the next page.**

$$R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

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

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

$$\text{Specific heat of H}_2\text{O(s)} = 2.03 \text{ J / g} \cdot ^\circ\text{C}$$

$$\text{Specific heat of H}_2\text{O(l)} = 4.18 \text{ J / g} \cdot ^\circ\text{C}$$

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

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

$$\text{density(H}_2\text{O, l)} = 1.00 \text{ g/mL}$$

$$\Delta H_{\text{fus}}^\circ[\text{H}_2\text{O}] = 6.01 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{vap}}^\circ[\text{H}_2\text{O}] = 44.0 \text{ kJ mol}^{-1}$$

$$1 \text{ atm} = 101.325 \text{ kPa} = 760 \text{ mm Hg}$$

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

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

$$1 \text{ Hz} = 1 \text{ cycle/s}$$

$$0^\circ\text{C} = 273.15 \text{ K}$$

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

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

De Broglie wavelength:

$$\lambda = h / mv = h / p$$

Hydrogen atom energy levels:

$$E_n = -R_H / n^2 = -2.178 \times 10^{-18} \text{ J} / n^2$$

Nernst Equation (the last two equations are for $T = 298.15 \text{ K}$):

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

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

Gibbs free energy of reaction: $\Delta G = \Delta G^\circ + RT \ln Q$

The roots of quadratic equation, $ax^2 + bx + c = 0$, are given by $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

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.

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PERIODIC TABLE OF THE ELEMENTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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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	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	72 Th 232.04	73 Pa 231.04	74 U 238.03	75 Np 237.05	76 Pu [244]	77 Am [243]	78 Cm [247]	79 Bk [247]	80 Cf [251]	81 Es [252]	82 Fm [257]	83 Md [258]	84 No [259]	85 Lr [262]	86 Fr [223]	87 Ra 226.03	88 Ac 227.03	89 Th 232.04	90 Pa 231.04	91 U 238.03	92 Np 237.05	93 Pu [244]	94 Am [243]	95 Cm [247]	96 Bk [247]	97 Cf [251]	98 Es [252]	99 Fm [257]	100 Md [258]	101 No [259]	102 Lr [262]	103 Th 232.04	104 Pa 231.04	105 U 238.03	106 Np 237.05	107 Pu [244]	108 Am [243]	109 Cm [247]	110 Bk [247]	111 Cf [251]	112 Es [252]	113 Fm [257]	114 Md [258]	115 No [259]	116 Lr [262]	117 Th 232.04	118 Pa 231.04	119 U 238.03	120 Np 237.05	121 Pu [244]	122 Am [243]	123 Cm [247]	124 Bk [247]	125 Cf [251]	126 Es [252]	127 Fm [257]	128 Md [258]	129 No [259]	130 Lr [262]	131 Th 232.04	132 Pa 231.04	133 U 238.03	134 Np 237.05	135 Pu [244]	136 Am [243]	137 Cm [247]	138 Bk [247]	139 Cf [251]	140 Es [252]	141 Fm [257]	142 Md [258]	143 No [259]	144 Lr [262]	145 Th 232.04	146 Pa 231.04	147 U 238.03	148 Np 237.05	149 Pu [244]	150 Am [243]	151 Cm [247]	152 Bk [247]	153 Cf [251]	154 Es [252]	155 Fm [257]	156 Md [258]	157 No [259]	158 Lr [262]	159 Th 232.04	160 Pa 231.04	161 U 238.03	162 Np 237.05	163 Pu [244]	164 Am [243]	165 Cm [247]	166 Bk [247]	167 Cf [251]	168 Es [252]	169 Fm [257]	170 Md [258]	171 No [259]	172 Lr [262]	173 Th 232.04	174 Pa 231.04	175 U 238.03	176 Np 237.05	177 Pu [244]	178 Am [243]	179 Cm [247]	180 Bk [247]	181 Cf [251]	182 Es [252]	183 Fm [257]	184 Md [258]	185 No [259]	186 Lr [262]	187 Th 232.04	188 Pa 231.04	189 U 238.03	190 Np 237.05	191 Pu [244]	192 Am [243]	193 Cm [247]	194 Bk [247]	195 Cf [251]	196 Es [252]	197 Fm [257]	198 Md [258]	199 No [259]	200 Lr [262]	201 Th 232.04	202 Pa 231.04	203 U 238.03	204 Np 237.05	205 Pu [244]	206 Am [243]	207 Cm [247]	208 Bk [247]	209 Cf [251]	210 Es [252]	211 Fm [257]	212 Md [258]	213 No [259]	214 Lr [262]	215 Th 232.04	216 Pa 231.04	217 U 238.03	218 Np 237.05	219 Pu [244]	220 Am [243]	221 Cm [247]	222 Bk [247]	223 Cf [251]	224 Es [252]	225 Fm [257]	226 Md [258]	227 No [259]	228 Lr [262]	229 Th 232.04	230 Pa 231.04	231 U 238.03	232 Np 237.05	233 Pu [244]	234 Am [243]	235 Cm [247]	236 Bk [247]	237 Cf [251]	238 Es [252]	239 Fm [257]	240 Md [258]	241 No [259]	242 Lr [262]	243 Th 232.04	244 Pa 231.04	245 U 238.03	246 Np 237.05	247 Pu [244]	248 Am [243]	249 Cm [247]	250 Bk [247]	251 Cf [251]	252 Es [252]	253 Fm [257]	254 Md [258]	255 No [259]	256 Lr [262]	257 Th 232.04	258 Pa 231.04	259 U 238.03	260 Np 237.05	261 Pu [244]	262 Am [243]	263 Cm [247]	264 Bk [247]	265 Cf [251]	266 Es [252]	267 Fm [257]	268 Md [258]	269 No [259]	270 Lr [262]	271 Th 232.04	272 Pa 231.04	273 U 238.03	274 Np 237.05	275 Pu [244]	276 Am [243]	277 Cm [247]	278 Bk [247]	279 Cf [251]	280 Es [252]	281 Fm [257]	282 Md [258]	283 No [259]	284 Lr [262]	285 Th 232.04	286 Pa 231.04	287 U 238.03	288 Np 237.05	289 Pu [244]	290 Am [243]	291 Cm [247]	292 Bk [247]	293 Cf [251]	294 Es [252]	295 Fm [257]	296 Md [258]	297 No [259]	298 Lr [262]	299 Th 232.04	300 Pa 231.04	301 U 238.03	302 Np 237.05	303 Pu [244]	304 Am [243]	305 Cm [247]	306 Bk [247]	307 Cf [251]	308 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[243]	459 Cm [247]	460 Bk [247]	461 Cf [251]	462 Es [252]	463 Fm [257]	464 Md [258]	465 No [259]	466 Lr [262]	467 Th 232.04	468 Pa 231.04	469 U 238.03	470 Np 237.05	471 Pu [244]	472 Am [243]	473 Cm [247]	474 Bk [247]	475 Cf [251]	476 Es [252]	477 Fm [257]	478 Md [258]	479 No [259]	480 Lr [262]	481 Th 232.04	482 Pa 231.04	483 U 238.03	484 Np 237.05	485 Pu [244]	486 Am [243]	487 Cm [247]	488 Bk [247]	489 Cf [251]	490 Es [252]	491 Fm [257]	492 Md [258]	493 No [259]	494 Lr [262]	495 Th 232.04	496 Pa 231.04	497 U 238.03	498 Np 237.05	499 Pu [244]	500 Am [243]	501 Cm [247]	502 Bk [247]	503 Cf [251]	504 Es [252]	505 Fm [257]	506 Md [258]	507 No [259]	508 Lr [262]	509 Th 232.04	510 Pa 231.04	511 U 238.03	512 Np 237.05	513 Pu [244]	514 Am [243]	515 Cm [247]	516 Bk [247]	517 Cf [251]	518 Es [252]	519 Fm [257]	520 Md [258]	521 No [259]	522 Lr [262]	523 Th 232.04	524 Pa 231.04	525 U 238.03	526 Np 237.05	527 Pu [244]	528 Am [243]	529 Cm [247]	530 Bk [247]	531 Cf [251]	532 Es [252]	533 Fm [257]	534 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238.03	610 Np 237.05	611 Pu [244]	612 Am [243]	613 Cm [247]	614 Bk [247]	615 Cf [251]	616 Es [252]	617 Fm [257]	618 Md [258]	619 No [259]	620 Lr [262]	621 Th 232.04	622 Pa 231.04	623 U 238.03	624 Np 237.05	625 Pu [244]	62