

Name: \_\_\_\_\_

Student number: \_\_\_\_\_

Chemistry 1A03/1E03

December, 2005

VERSION 1

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Duration: 3 hours

MCMASTER UNIVERSITY FINAL EXAMINATION

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This exam contains 28 numbered pages. There are **35** multiple-choice questions appearing on pages numbered 3 to 23. Pages 24-26 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 pages to view the periodic table and the data provided.

**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.

**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 25 are each worth 2 marks, questions 26 – 35 are each worth 3 marks; the total marks available are 80. 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 CORRECT COLUMN 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).

Only Casio FX 991 electronic calculators may be used; but they must NOT be transferred between students. Use of periodic tables or any aids, other than those provided, is not allowed.

Do not make contact with other students directly. Try to keep your eyes on your own paper – looking around the room may be interpreted as an attempt to copy. Academic dishonesty may include, among other actions, communication of any kind (verbal, visual, *etc.*) between students, sharing of materials between students, copying or looking at other students' work. If you have a problem please ask the invigilator to deal with it for you.

Any questions not relevant to Chem 1A03 Fall 2008 have been covered up, to prevent confusion. Please note blank pages when printing. Exam answers will not be posted, but you are welcome to discuss them in WebCT bulletin board or in office hours/help centre.

**Questions 1 – 25 are worth 2 marks each.**

1. A sample of hydrogen atoms have their electrons excited to various energy levels; this is followed by emission of light. **Which one of the following transitions** would produce the photons with the shortest wavelength?

- (A)  $n = 2 \rightarrow n = 1$
- (B)  $n = 3 \rightarrow n = 2$
- (C)  $n = 7 \rightarrow n = 6$
- (D)  $n = 5 \rightarrow n = 2$
- (E)  $n = 4 \rightarrow n = 1$

2. The O–H bond energy in water is approximately  $467 \text{ kJ mol}^{-1}$ . The photon with just enough energy to break one O–H bond has a **wavelength (in nm)** of

- (A) 256 nm
- (B) 23.7 nm
- (C) 4130 nm
- (D) 213 nm
- (E) 467 nm

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4. Select the statement that is **FALSE** regarding the perchlorate anion,  $\text{ClO}_4^-$ , with a charge minimized Lewis structure.

- (A) The formal charge of Cl is 0.
- (B) The oxidation state of Cl is +7.
- (C) The average Cl–O bond order is  $1\frac{1}{2}$ .
- (D) The shape of the anion is tetrahedral.
- (E) The anion has 18 nonbonding valence electrons.

5. Select the **ONE TRUE** statement concerning the following molecules:



- (A) One of these molecules is an exception to the octet rule.
- (B) There are lone pairs of electrons in all of these molecules.
- (C) All the H–A–H angles are equal in these three molecules (A is the central atom).
- (D) H has a negative oxidation state in at least one of these molecules.
- (E) Considering bonding and nonbonding electron pairs, all these molecules have the same VSEPR electron-group arrangement.

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6. Which **ONE** of the following pairs of reagents produces **no visible change** when they are mixed together?

- (A)  $\text{Cl}_2(\text{g}) + \text{KBr}(\text{aq})$
- (B)  $\text{KCl}(\text{aq}) + \text{AgClO}_4(\text{aq})$
- (C)  $\text{Zn}(\text{s}) + \text{HI}(\text{aq})$
- (D)  $\text{Na}_2\text{CO}_3(\text{s}) + \text{HCl}(\text{aq})$
- (E)  $\text{Cu}(\text{s}) + \text{HCl}(\text{aq})$

7. Given  $\Delta H_f^\circ(\text{NF}_3, \text{g}) = -132 \text{ kJ mol}^{-1}$  and the following bond energy (BE) data:

$\text{BE}(\text{N}_2) = 946 \text{ kJ mol}^{-1}$ ,  $\text{BE}(\text{F}_2) = 159 \text{ kJ mol}^{-1}$ , which of the following statements is(are) **FALSE**?

- (i) The average N-F bond energy in  $\text{NF}_3$  is  $281 \text{ kJ mol}^{-1}$ .
- (ii) The average N-F bond energy in  $\text{NF}_3$  is  $193 \text{ kJ mol}^{-1}$ .
- (iii)  $\Delta H_f^\circ(\text{F}(\text{g})) = +159 \text{ kJ mol}^{-1}$

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

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8. Acetylene gas ( $\text{C}_2\text{H}_2$  (g)) has a standard enthalpy of formation of  $+226 \text{ kJ mol}^{-1}$ . Under pressure, acetylene can react with itself to form benzene ( $\text{C}_6\text{H}_6$  (l)), whose standard enthalpy of formation is  $+49 \text{ kJ mol}^{-1}$ . The **enthalpy of reaction** of forming 1.0 mole of benzene from acetylene is:

- (A)  $-177 \text{ kJ}$
- (B)  $-275 \text{ kJ}$
- (C)  $-629 \text{ kJ}$
- (D)  $-727 \text{ kJ}$
- (E)  $-210 \text{ kJ}$

9. Which of the following statements is(are) **FALSE**?

- (i) The sign of work ( $w$ ) done by a system is negative.
- (ii) If  $\Delta E$  is zero and  $w$  is positive, then heat ( $q$ ) must be positive.
- (iii) Electrical work can be calculated from charge transferred  $\times$  voltage.
- (iv) An ideal ice calorimeter does not exchange heat with its surroundings.
- (v) When a gas expands at constant pressure,  $w$  for the gas is positive.

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

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10. The standard enthalpies of combustion of acetylene ( $\text{C}_2\text{H}_2(\text{g})$ ), hydrogen ( $\text{H}_2(\text{g})$ ) and ethane ( $\text{C}_2\text{H}_6(\text{g})$ ) are  $-1305 \text{ kJ mol}^{-1}$ ,  $-285.8 \text{ kJ mol}^{-1}$  and  $-1541 \text{ kJ mol}^{-1}$ , respectively, at 298.15 K. What is the **standard enthalpy of the reaction (kJ)** of acetylene plus hydrogen to form one mole of ethane?

- (A)  $-335.6 \text{ kJ}$
- (B)  $-49.8 \text{ kJ}$
- (C)  $-3417.6 \text{ kJ}$
- (D)  $+49.8 \text{ kJ}$
- (E)  $-2274.4 \text{ kJ}$

11. In a thermochemistry experiment, a reaction between 4 M hydrochloric acid and 4 M sodium hydroxide is carried out in an ice calorimeter. Select the **FALSE** statement(s).

- (i) The reaction enthalpy determined in the experiment will be the same if 4 M nitric acid is used instead of 4 M hydrochloric acid.
- (ii) The reaction leads to an increase in volume of the water plus ice mixture inside the calorimeter.
- (iii) The ice calorimeter works at  $0^\circ \text{C}$  and at constant pressure.
- (iv) Measured volume change = (volume of ice melted) – (volume of water produced from melting ice).

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

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12. “Handwarmers” for use in cold weather consist of 4.00 g of finely-divided iron, which oxidizes to  $\text{Fe}_2\text{O}_3$  when opened to air. Assume that the total heat capacity of your hand and the handwarmer is  $836.8 \text{ J K}^{-1}$ . The standard heat of formation of  $\text{Fe}_2\text{O}_3$  is  $-822.2 \text{ kJ mol}^{-1}$ . If the heat from a handwarmer was released to your hand all at once, the **temperature change in your hand would be:**

- (A) 17.6 K
- (B) 70.4 K
- (C) 35.2 K
- (D) 3.52 K
- (E) 7.04 K

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

- (i)  $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$
- (ii)  $\text{Pb}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{PbSO}_4(\text{s})$
- (iii)  $\text{O}_3(\text{g}) \rightarrow \text{O}_2(\text{g}) + \text{O}(\text{g})$
- (iv)  $5 \text{C}(\text{s}) + 4 \text{KNO}_3(\text{s}) \rightarrow 5 \text{CO}_2(\text{g}) + 2 \text{N}_2(\text{g}) + 2 \text{K}_2\text{O}(\text{s})$

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

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14. Consider the reaction  $\text{H}_2(\text{g}) + \text{S}(\text{s}) \rightarrow \text{H}_2\text{S}(\text{g})$  for which  $\Delta H^\circ = -20 \text{ kJ}$  and  $\Delta S^\circ = +43 \text{ J K}^{-1}$  at 298.15 K. Choose the **TRUE** statement.

- (A) The reaction is not spontaneous at 298.15 K.
- (B) The reaction is not spontaneous at any temperature.
- (C) The reaction is spontaneous only above a temperature of 465 K.
- (D) The reaction is driven by enthalpy only.
- (E) The reaction is spontaneous at all temperatures.

15. Select the **FALSE** statement from the following:

- (A) The entropy of a system is a measure of its disorder.
- (B) The standard entropy change for a chemical reaction can be calculated from the absolute entropies of reactants and products.
- (C) For a system at equilibrium,  $\Delta H_{\text{sys}} = -T\Delta S_{\text{sys}}$ .
- (D) For a spontaneous chemical reaction at 298.15 K and 1 atm,  $\Delta G^\circ < 0$ .
- (E)  $\Delta S^\circ < 0$  for the reaction  $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{HOOH}(\text{g})$ .

16. Arrange the following substances in order of **increasing molar entropy** at 25°C:

$\text{H}_2\text{O}(\text{l})$ ,  $\text{Na}(\text{s})$ ,  $\text{Ne}(\text{g})$ , and  $\text{SO}_2(\text{g})$

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



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17. The melting point of  $\text{H}_2\text{O}$  is  $0.00^\circ\text{C}$ . The enthalpy of fusion (melting) for  $\text{H}_2\text{O}$  is  $6.01 \text{ kJ mol}^{-1}$ . What is the **entropy of fusion** ( $\text{J mol}^{-1} \text{ K}^{-1}$ ) for  $\text{H}_2\text{O}$ ?

- (A)  $+22.0 \text{ J mol}^{-1} \text{ K}^{-1}$
- (B)  $-22.0 \text{ J mol}^{-1} \text{ K}^{-1}$
- (C)  $+1.64 \text{ J mol}^{-1} \text{ K}^{-1}$
- (D)  $+45.5 \text{ J mol}^{-1} \text{ K}^{-1}$
- (E)  $-45.5 \text{ J mol}^{-1} \text{ K}^{-1}$

18. Which of the following statements is(are) **FALSE**?

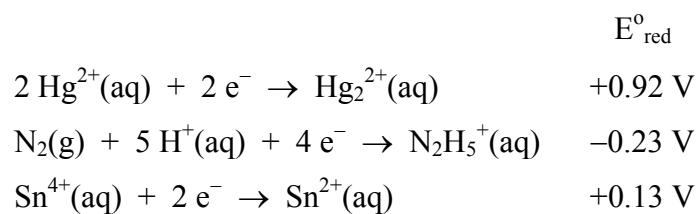
- (i) All spontaneous processes increase the total entropy of the universe.
- (ii)  $\Delta G_{\text{sys}} < 0$  for all spontaneous processes.
- (iii) The normal boiling point of a liquid is given by  $\Delta H_{\text{vaporization}} / \Delta S_{\text{vaporization}}$ .
- (iv) At a given temperature, a reaction proceeds spontaneously in the forward direction if its reaction quotient is larger than its equilibrium constant.

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

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21. Given the following standard reduction potentials, identify the **best reducing agent**.



- (A)  $\text{Sn}^{2+}(\text{aq})$
- (B)  $\text{Hg}_2^{2+}(\text{aq})$
- (C)  $\text{N}_2(\text{g})$
- (D)  $\text{Hg}_2^{2+}(\text{aq})$
- (E)  $\text{N}_2\text{H}_5^+(\text{aq})$

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22. 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,  $T = 37\text{ }^{\circ}\text{C}$  and a one-electron transfer ( $n = 1$ ).

- (A) 0.198
- (B) 0.0862
- (C) 0.0615
- (D) 0.0592
- (E) 0.0267

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**Questions 26 – 35 are worth 3 marks each.**

26. Which of the following statements is **FALSE**?

- (i) An  $\text{Al}^{3+}$  cation in its ground electronic state has no unpaired electrons.
- (ii) In the  $\text{He}^+$  cation, the 3s and 3p orbitals have the same energy.
- (iii) In the H atom, the photon from the transition from  $n=2$  to  $n=1$  is outside the visible range of the spectrum (400-700 nm).
- (iv) B has a larger first ionization energy than Al.

- (A) None is false
- (B) i
- (C) ii
- (D) iii
- (E) iv

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27. Which of the following statements is(are) **TRUE**?

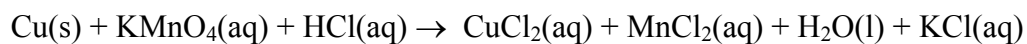
- (i)  $\text{TeCl}_2$  is a V-shaped (or “bent”) molecule.
- (ii) All of the atoms of  $\text{TeCl}_3^+$  are in the same plane.
- (iii)  $\text{TeCl}_4$  has one nonbonding pair of electrons on tellurium.

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

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28. A copper penny weighing 1.868 g is completely dissolved in an excess of hydrochloric acid and  $\text{KMnO}_4(\text{aq})$ , according to the reaction (*note that the reaction is unbalanced*):



The resultant solution is diluted to a final volume of 60.00 mL with water. What is the **molarity (in units of  $\text{mol L}^{-1}$ ) of manganese(II) chloride** in the final solution?

- (A)  $0.3919 \text{ mol L}^{-1}$
- (B)  $0.01176 \text{ mol L}^{-1}$
- (C)  $0.1960 \text{ mol L}^{-1}$
- (D)  $0.4899 \text{ mol L}^{-1}$
- (E)  $0.2746 \text{ mol L}^{-1}$

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29. Consider the reaction  $\text{Si(s)} + 2 \text{H}_2\text{(g)} \rightarrow \text{SiH}_4\text{(g)}$ . Use the data below to identify the **TRUE** statement(s).

DATA:

At 25 °C,  $K = 1.06 \times 10^{-10}$  for the formation reaction of  $\text{SiH}_4\text{(g)}$ .

$$\Delta H_f^\circ(\text{SiH}_4, \text{g}) = 34.3 \text{ kJ mol}^{-1}$$

$$S^\circ(\text{SiH}_4, \text{g}) = 204.62 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$S^\circ(\text{H}_2, \text{g}) = 130.68 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$S^\circ(\text{Si, s}) = 18.83 \text{ J K}^{-1} \text{ mol}^{-1}$$

- (i)  $\Delta S^\circ > 0$  for the forward reaction.
- (ii) The reverse reaction is spontaneous at all temperatures.
- (iii) If  $P(\text{H}_2) = 100 \text{ atm}$  at equilibrium at 25 °C, then  $P(\text{SiH}_4) = 1.06 \times 10^{-6} \text{ atm}$ .

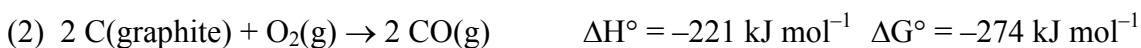
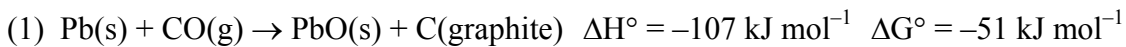
- (A) i
- (B) ii
- (C) iii
- (D) ii, iii
- (E) i, ii, iii



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30. Consider the following two reactions, with thermodynamic data at 298.15 K:



Which of the following statements is(are) **FALSE**? (Assume  $\Delta H^\circ$  and  $\Delta S^\circ$  are independent of temperature.)

(i)  $\Delta G_f^\circ[\text{PbO(s)}] = +188 \text{ kJ mol}^{-1}$  .

(ii) Both reactions are spontaneous under standard conditions at room temperature.

(iii)  $\Delta S^\circ$  for reaction 2 is  $-178 \text{ J K}^{-1} \text{ mol}^{-1}$  at 298.15 K.

(iv) Reaction 2 is spontaneous at 500 °C when the partial pressures of  $\text{O}_2$  and  $\text{CO}$  are 1 atm each.

(A) i

(B) i, ii

(C) iii

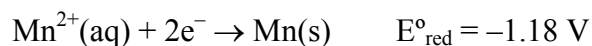
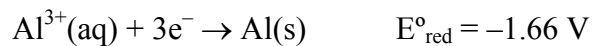
(D) iv

(E) i, iii

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31. Find the **FALSE** statements about the voltaic cell based on the two reduction half-reactions below. The initial ion concentrations are  $[\text{Al}^{3+}] = 0.01 \text{ M}$ ,  $[\text{Mn}^{2+}] = 0.1 \text{ M}$ .



- (i)  $\text{Al}(\text{s})$  is a stronger reducing agent than  $\text{Mn}(\text{s})$ .
- (ii) The cell diagram is  $\text{Al}(\text{s}) \mid \text{Al}^{3+}(\text{aq}) \parallel \text{Mn}^{2+}(\text{aq}) \mid \text{Mn}(\text{s})$ .
- (iii) For the balanced cell reaction the reaction quotient  $Q = [\text{Al}^{3+}] / [\text{Mn}^{2+}]$ .
- (iv) For the initial reaction quotient  $Q$ ,  $\log_{10} Q = -1$ .
- (v) When the cell is put into operation, the initial cell potential is  $+0.48 \text{ V}$ .

(A) i, ii, iv

(B) ii, iii

(C) ii, v

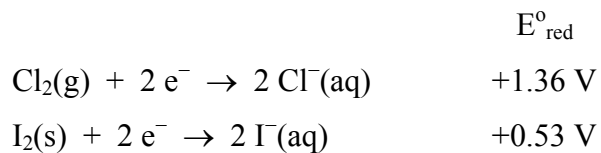
(D) iii, v

(E) i, iv

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32. An electrochemical cell is based on the spontaneous redox reaction associated with the standard reduction potentials given below. If the initial concentrations of  $\text{Cl}^-(\text{aq})$  and  $\text{I}^-(\text{aq})$  are 1.15 M and 0.65 M, respectively, and the initial cell potential ( $E_{\text{cell}}$ ) is +0.807 V, calculate the initial **partial pressure of  $\text{Cl}_2(\text{g})$**  (in atm) in the cell.

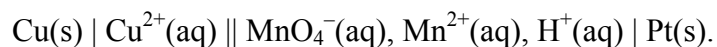


- (A) 1.3 atm
- (B) 1.9 atm
- (C) 0.30 atm
- (D) 0.52 atm
- (E) 1.4 atm

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33. Find the **FALSE** statement(s) about the following electrochemical cell:



- (i) Decreasing the concentration of  $\text{Cu}^{2+}(\text{aq})$  in the cell will increase the cell voltage.
- (ii) Anions in the salt bridge flow towards the anode.
- (iii)  $\text{H}_2(\text{g})$  is produced at the Pt(s) electrode.
- (iv) Electrons flow from the Cu electrode towards the Pt electrode.
- (v) Pt(s) serves as an inert (inactive) anode.

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

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**Some general data are provided on this page and the next page.  
A periodic table is provided on page 28.**

**Other data appear with the questions.**

$$\text{STP} = 273.15 \text{ K}, 1 \text{ atm}$$

$$F = 96485 \text{ C/mol}$$

$$R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} \quad N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

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

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

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

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

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

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

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

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

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

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

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

$$\Delta x \Delta p \geq h / 4\pi$$

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

Note  $R_H$  is the energy form of the Rydberg constant for hydrogen

$$w = -p\Delta V$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$E = E^\circ - (RT/nF) \ln Q = E^\circ - (0.0257/n) \ln Q = E^\circ - (0.0592/n) \log Q$$

$$\text{Specific heat of water} = 4.184 \text{ J / g}^\circ\text{C}$$

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

### ***Soluble Ionic Compounds***

1. All common compounds of Group 1A(1) ions ( $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , *etc.*) and ammonium ion ( $\text{NH}_4^+$ ) are soluble.
2. All common nitrates ( $\text{NO}_3^-$ ), acetates ( $\text{CH}_3\text{COO}^-$  or  $\text{C}_2\text{H}_3\text{O}_2^-$ ), and most perchlorates ( $\text{ClO}_4^-$ ) are soluble.
3. All common chlorides ( $\text{Cl}^-$ ), bromides ( $\text{Br}^-$ ), and iodides ( $\text{I}^-$ ) are soluble, *except* those of  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^+$ , and  $\text{Hg}_2^{2+}$ .
4. All common sulfates ( $\text{SO}_4^{2-}$ ) are soluble, *except* those of  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$ , and  $\text{Pb}^{2+}$ .

### ***Insoluble Ionic Compounds***

1. All common metal hydroxides ( $\text{OH}^-$ ) are insoluble, *except* those of Group 1A(1) and the larger members of Group 2A(2) (beginning with  $\text{Ca}^{2+}$ ).
2. All common carbonates ( $\text{CO}_3^{2-}$ ) and phosphates ( $\text{PO}_4^{3-}$ ) are insoluble, *except* those of Group 1A(1) and  $\text{NH}_4^+$ .
3. All common sulfides ( $\text{S}^{2-}$ ) are insoluble *except* those of Group 1A(1), Group 2A(2), and  $\text{NH}_4^+$ .

# Periodic Table of the Elements

1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1 H 1.008	2 He 4.003	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 Na 22.99	10 Mg 24.31	11 Al 26.98	12 Si 28.09	13 P 30.97	14 S 32.07	15 Cl 35.45	16 Ar 39.95
17 K 39.10	18 Ca 40.08	19 Sc 44.96	20 Ti 47.88	21 V 50.94	22 Cr 52.00	23 Mn 54.94	24 Fe 55.85
25 Rb 85.47	26 Sr 87.62	27 Y 88.91	28 Zr 91.22	29 Nb 92.91	30 Mo 95.94	31 Tc (98)	32 Ru 101.1
33 Cs 132.9	34 Ba 137.3	35 La 138.9	36 Hf 178.5	37 Ta 180.9	38 W 183.9	39 Re 186.2	40 Os 190.2
41 Fr (223)	42 Ra (226)	43 Ac (227)	44 Rf (261)	45 Db (262)	46 Sg (266)	47 Bh (262)	48 Hs (265)
49 Tl 204.4	50 Pb 207.2	51 Bi 209.0	52 Po (209)	53 At (210)	54 Rn (222)	55 Xe 131.3	56 Kr 83.80
57 In 114.8	58 Sn 118.7	59 Sb 121.8	60 Te 127.6	61 I 126.9	62 Xe 131.3	63 Kr 83.80	64 Ar 39.95
65 Ga 69.72	66 Ge 72.61	67 As 74.92	68 Se 78.96	69 Br 79.90	70 Kr 83.80	71 Ar 39.95	72 Ne 20.18
73 Zn 65.39	74 Cu 63.55	75 Ni 58.69	76 Co 58.93	77 Fe 55.85	78 Mn 54.94	79 Cr 52.00	80 V 50.94
81 Cd 112.4	82 Ag 107.9	83 Pd 106.4	84 Rh 102.9	85 Ru 101.1	86 Os 190.2	87 Ir 192.2	88 Pt 195.1
89 Hg 200.6	90 Au 197.0	91 Pt 195.1	92 Ir 192.2	93 Rh 102.9	94 Ru 101.1	95 Os 190.2	96 Re 186.2
97 Tl 204.4	98 Pb 207.2	99 Bi 209.0	100 Po (209)	101 At (210)	102 Rn (222)	103 Xe 131.3	104 Kr 83.80
105 Ga 69.72	106 Ge 72.61	107 As 74.92	108 Se 78.96	109 Br 79.90	110 Kr 83.80	111 Ar 39.95	112 Ne 20.18
113 In 114.8	114 Sn 118.7	115 Sb 121.8	116 Te 127.6	117 I 126.9	118 Xe 131.3	119 Kr 83.80	120 Ar 39.95
121 Cd 112.4	122 Ag 107.9	123 Pd 106.4	124 Rh 102.9	125 Ru 101.1	126 Os 190.2	127 Ir 192.2	128 Pt 195.1
129 Hg 200.6	130 Au 197.0	131 Pt 195.1	132 Ir 192.2	133 Rh 102.9	134 Ru 101.1	135 Os 190.2	136 Re 186.2
137 Tl 204.4	138 Pb 207.2	139 Bi 209.0	140 Po (209)	141 At (210)	142 Rn (222)	143 Xe 131.3	144 Kr 83.80
145 Ga 69.72	146 Ge 72.61	147 As 74.92	148 Se 78.96	149 Br 79.90	150 Kr 83.80	151 Ar 39.95	152 Ne 20.18
153 Zn 65.39	154 Cu 63.55	155 Ni 58.69	156 Co 58.93	157 Fe 55.85	158 Mn 54.94	159 Cr 52.00	160 V 50.94
161 Cd 112.4	162 Ag 107.9	163 Pd 106.4	164 Rh 102.9	165 Ru 101.1	166 Os 190.2	167 Ir 192.2	168 Pt 195.1
169 Hg 200.6	170 Au 197.0	171 Pt 195.1	172 Ir 192.2	173 Rh 102.9	174 Ru 101.1	175 Os 190.2	176 Re 186.2
177 Tl 204.4	178 Pb 207.2	179 Bi 209.0	180 Po (209)	181 At (210)	182 Rn (222)	183 Xe 131.3	184 Kr 83.80
185 Ga 69.72	186 Ge 72.61	187 As 74.92	188 Se 78.96	189 Br 79.90	190 Kr 83.80	191 Ar 39.95	192 Ne 20.18
193 Zn 65.39	194 Cu 63.55	195 Ni 58.69	196 Co 58.93	197 Fe 55.85	198 Mn 54.94	199 Cr 52.00	200 V 50.94
201 Cd 112.4	202 Ag 107.9	203 Pd 106.4	204 Rh 102.9	205 Ru 101.1	206 Os 190.2	207 Ir 192.2	208 Pt 195.1
209 Hg 200.6	210 Au 197.0	211 Pt 195.1	212 Ir 192.2	213 Rh 102.9	214 Ru 101.1	215 Os 190.2	216 Re 186.2
217 Tl 204.4	218 Pb 207.2	219 Bi 209.0	220 Po (209)	221 At (210)	222 Rn (222)	223 Xe 131.3	224 Kr 83.80
225 Ga 69.72	226 Ge 72.61	227 As 74.92	228 Se 78.96	229 Br 79.90	230 Kr 83.80	231 Ar 39.95	232 Ne 20.18
233 Zn 65.39	234 Cu 63.55	235 Ni 58.69	236 Co 58.93	237 Fe 55.85	238 Mn 54.94	239 Cr 52.00	240 V 50.94
241 Cd 112.4	242 Ag 107.9	243 Pd 106.4	244 Rh 102.9	245 Ru 101.1	246 Os 190.2	247 Ir 192.2	248 Pt 195.1
249 Hg 200.6	250 Au 197.0	251 Pt 195.1	252 Ir 192.2	253 Rh 102.9	254 Ru 101.1	255 Os 190.2	256 Re 186.2
257 Tl 204.4	258 Pb 207.2	259 Bi 209.0	260 Po (209)	261 At (210)	262 Rn (222)	263 Xe 131.3	264 Kr 83.80
265 Ga 69.72	266 Ge 72.61	267 As 74.92	268 Se 78.96	269 Br 79.90	270 Kr 83.80	271 Ar 39.95	272 Ne 20.18
273 Zn 65.39	274 Cu 63.55	275 Ni 58.69	276 Co 58.93	277 Fe 55.85	278 Mn 54.94	279 Cr 52.00	280 V 50.94
281 Cd 112.4	282 Ag 107.9	283 Pd 106.4	284 Rh 102.9	285 Ru 101.1	286 Os 190.2	287 Ir 192.2	288 Pt 195.1
289 Hg 200.6	290 Au 197.0	291 Pt 195.1	292 Ir 192.2	293 Rh 102.9	294 Ru 101.1	295 Os 190.2	296 Re 186.2
297 Tl 204.4	298 Pb 207.2	299 Bi 209.0	300 Po (209)	301 At (210)	302 Rn (222)	303 Xe 131.3	304 Kr 83.80
305 Ga 69.72	306 Ge 72.61	307 As 74.92	308 Se 78.96	309 Br 79.90	310 Kr 83.80	311 Ar 39.95	312 Ne 20.18
313 Zn 65.39	314 Cu 63.55	315 Ni 58.69	316 Co 58.93	317 Fe 55.85	318 Mn 54.94	319 Cr 52.00	320 V 50.94
321 Cd 112.4	322 Ag 107.9	323 Pd 106.4	324 Rh 102.9	325 Ru 101.1	326 Os 190.2	327 Ir 192.2	328 Pt 195.1
329 Hg 200.6	330 Au 197.0	331 Pt 195.1	332 Ir 192.2	333 Rh 102.9	334 Ru 101.1	335 Os 190.2	336 Re 186.2
337 Tl 204.4	338 Pb 207.2	339 Bi 209.0	340 Po (209)	341 At (210)	342 Rn (222)	343 Xe 131.3	344 Kr 83.80
345 Ga 69.72	346 Ge 72.61	347 As 74.92	348 Se 78.96	349 Br 79.90	350 Kr 83.80	351 Ar 39.95	352 Ne 20.18
353 Zn 65.39	354 Cu 63.55	355 Ni 58.69	356 Co 58.93	357 Fe 55.85	358 Mn 54.94	359 Cr 52.00	360 V 50.94
361 Cd 112.4	362 Ag 107.9	363 Pd 106.4	364 Rh 102.9	365 Ru 101.1	366 Os 190.2	367 Ir 192.2	368 Pt 195.1
369 Hg 200.6	370 Au 197.0	371 Pt 195.1	372 Ir 192.2	373 Rh 102.9	374 Ru 101.1	375 Os 190.2	376 Re 186.2
377 Tl 204.4	378 Pb 207.2	379 Bi 209.0	380 Po (209)	381 At (210)	382 Rn (222)	383 Xe 131.3	384 Kr 83.80
385 Ga 69.72	386 Ge 72.61	387 As 74.92	388 Se 78.96	389 Br 79.90	390 Kr 83.80	391 Ar 39.95	392 Ne 20.18
393 Zn 65.39	394 Cu 63.55	395 Ni 58.69	396 Co 58.93	397 Fe 55.85	398 Mn 54.94	399 Cr 52.00	400 V 50.94
401 Cd 112.4	402 Ag 107.9	403 Pd 106.4	404 Rh 102.9	405 Ru 101.1	406 Os 190.2	407 Ir 192.2	408 Pt 195.1
409 Hg 200.6	410 Au 197.0	411 Pt 195.1	412 Ir 192.2	413 Rh 102.9	414 Ru 101.1	415 Os 190.2	416 Re 186.2
417 Tl 204.4	418 Pb 207.2	419 Bi 209.0	420 Po (209)	421 At (210)	422 Rn (222)	423 Xe 131.3	424 Kr 83.80
425 Ga 69.72	426 Ge 72.61	427 As 74.92	428 Se 78.96	429 Br 79.90	430 Kr 83.80	431 Ar 39.95	432 Ne 20.18
433 Zn 65.39	434 Cu 63.55	435 Ni 58.69	436 Co 58.93	437 Fe 55.85	438 Mn 54.94	439 Cr 52.00	440 V 50.94
441 Cd 112.4	442 Ag 107.9	443 Pd 106.4	444 Rh 102.9	445 Ru 101.1	446 Os 190.2	447 Ir 192.2	448 Pt 195.1
449 Hg 200.6	450 Au 197.0	451 Pt 195.1	452 Ir 192.2	453 Rh 102.9	454 Ru 101.1	455 Os 190.2	456 Re 186.2
457 Tl 204.4	458 Pb 207.2	459 Bi 209.0	460 Po (209)	461 At (210)	462 Rn (222)	463 Xe 131.3	464 Kr 83.80
465 Ga 69.72	466 Ge 72.61	467 As 74.92	468 Se 78.96	469 Br 79.90	470 Kr 83.80	471 Ar 39.95	472 Ne 20.18
473 Zn 65.39	474 Cu 63.55	475 Ni 58.69	476 Co 58.93	477 Fe 55.85	478 Mn 54.94	479 Cr 52.00	480 V 50.94
481 Cd 112.4	482 Ag 107.9	483 Pd 106.4	484 Rh 102.9	485 Ru 101.1	486 Os 190.2	487 Ir 192.2	488 Pt 195.1
489 Hg 200.6	490 Au 197.0	491 Pt 195.1	492 Ir 192.2	493 Rh 102.9	494 Ru 101.1	495 Os 190.2	496 Re 186.2
497 Tl 204.4	498 Pb 207.2	499 Bi 209.0	500 Po (209)	501 At (210)	502 Rn (222)	503 Xe 131.3	504 Kr 83.80
505 Ga 69.72	506 Ge 72.61	507 As 74.92	508 Se 78.96	509 Br 79.90	510 Kr 83.80	511 Ar 39.95	512 Ne 20.18
513 Zn 65.39	514 Cu 63.55	515 Ni 58.69	516 Co 58.93	517 Fe 55.85	518 Mn 54.94	519 Cr 52.00	520 V 50.94
521 Cd 112.4	522 Ag 107.9	523 Pd 106.4	524 Rh 102.9	525 Ru 101.1	526 Os 190.2	527 Ir 192.2	528 Pt 195.1
529 Hg 200.6	530 Au 197.0	531 Pt 195.1	532 Ir 192.2	533 Rh 102.9	534 Ru 101.1	535 Os 190.2	536 Re 186.2
537 Tl 204.4	538 Pb 207.2	539 Bi 209.0	540 Po (209)	541 At (210)	542 Rn (222)	543 Xe 131.3	544 Kr 83.80
545 Ga 69.72	546 Ge 72.61	547 As 74.92	548 Se 78.96	549 Br 79.90	550 Kr 83.80	551 Ar 39.95	552 Ne 20.18
553 Zn 65.39	554 Cu 63.55	555 Ni 58.69	556 Co 58.93	557 Fe 55.85	558 Mn 54.94	559 Cr 52.00	560 V 50.94
561 Cd 112.4	562 Ag 107.9	563 Pd 106.4	564 Rh 102.9	565 Ru 101.1	566 Os 190.2	567 Ir 192.2	568 Pt 195.1
569 Hg 200.6	570 Au 197.0	571 Pt 195.1	572 Ir 192.2	573 Rh 102.9	574 Ru 101.1	575 Os 190.2	576 Re 186.2
577 Tl 204.4	578 Pb 207.2	579 Bi 209.0	580 Po (209)	581 At (210)	582 Rn (222)	583 Xe 131.3	584 Kr 83.80
585 Ga 69.72	586 Ge 72.61	587 As 74.92	588 Se 78.96	589 Br 79.90	590 Kr 83.80	591 Ar 39.95	592 Ne 20.18
593 Zn 65.39	594 Cu 63.55	595 Ni 58.69	596 Co 58.93	597 Fe 55.85	598 Mn 54.94	599 Cr 52.00	600 V 50.94
601 Cd 112.4	602 Ag 107.9	603 Pd 106.4	604 Rh 102.9	605 Ru 101.1	606 Os 190.2	607 Ir 192.2	608 Pt 195.1
609 Hg 200.6	610 Au 197.0	611 Pt 195.1	612 Ir 192.2	613 Rh 102.9	614 Ru 101.1	615 Os 190.2	616 Re 186.2
617 Tl 204.4	618 Pb 207.2	619 Bi 209.0	620 Po (209)	621 At (210)	622 Rn (222)	623 Xe 131.3	624 Kr 83.80
625 Ga 69.72	626 Ge 72.61	627 As 74.92	628 Se 78.96	629 Br 79.90	630 Kr 83.80	631 Ar 39.95	632 Ne 20.18
633 Zn 65.39	634 Cu 63.55	635 Ni 58.69	636 Co 58.93	637 Fe 55.85	638 Mn 54.94	639 Cr 52.00	640 V 50.94
641 Cd 112.4	642 Ag 107.9	643 Pd 106.4	644 Rh 102.9	645 Ru 101.1	646 Os 190.2	647 Ir 192.2	648 Pt 195.1
649 Hg 200.6	650 Au 197.0	651 Pt 195.1	652 Ir 19				