Northern Arizona University **Exam #2**
CHM 151, General Chemistry I Dr. Brandon Cruickshank
Section 6, Fall 2008 October 23, 2008

Name (PRINT) KEY

INSTRUCTIONS:

- PRINT your name above and on the cover sheet.
- Code the answers to the True-False and Multiple-Choice questions on the scantron form. Mark **A** for true and **B** for false. There is only **one** correct answer for each multiple choice question. There is **no** partial credit given for this section.
- Show all work on the problems section because partial credit is awarded for this section.
- On the scantron form, write the color of your exam.
- Below your name at the top of this page, answer the following question. Who do you want to win the World Series – the Phillies or the Rays? You will receive 1 bonus pt.
- There are **90** points on this exam.

GOOD LUCK! ENJOY!!

PART I: True-false statements (3 points each)

1. The process, $H_2O(s) \rightarrow H_2O(l)$, is exothermic. **FALSE**

2. $CH_3COOH(aq)$ is a weak acid. **TRUE**

3. Blue light has a greater frequency than red light. **TRUE**

4. In a barium atom, the 5*s* orbital is higher in energy than the 4*d* orbitals. **FALSE**

PART II: Multiple Choice (3 points each)

5. X-rays have *shorter* wavelengths than ultraviolet-rays. Which of the following statements is **true**?

[a] X-rays have lower frequencies than UV-rays.
[b] X-rays travel faster than UV-rays.
[c] X-rays are higher energy than UV-rays. *
[d] X-rays have a larger amplitude than UV-rays.
[e] none of the above statements is true.

6. Given the three statements below, which is the best answer?

I. Although the wavelength and frequency of light can change, the energy of light remains constant.
II. An important consequence of quantum theory is that the energy of various electronic states in atoms is at fixed discrete levels.
III. The energy of an electronic state in a hydrogen atom is dependent on the principal quantum number, *n*.

[a] I and II are true, III is false **[b] II and III are true, I is false ***
[c] I and III are true, II is false [d] all are true [e] all are false

7. Bluetooth wireless cell phone headsets operate in the 2.40 GHz frequency band. What is the **wavelength** of this radiation? [1 GHz = 1×10^9 Hz].

[a] 1.25×10^4 m [b] 7.20×10^{17} m [c] 8.00 m [d] 1350 m **[e] 0.125 m ***

8. Which of the following transitions in the spectrum of the hydrogen atom is caused by the **absorption** of a photon with the **smallest energy**?

[a] $n = 2$ to $n = 3$* [b] $n = 2$ to $n = 4$ [c] $n = 1$ to $n = 4$ [d] $n = 3$ to $n = 1$ [e] $n = 7$ to $n = 6$

9. Calculate the **wavelength** of the light emitted by a hydrogen atom during the electronic transition from the $n = 4$ to the $n = 1$ energy level.

[a] 1.22×10^{-7} m [b] 1.46×10^{-6} m [c] 2.12×10^{-25} m [d] 6.08×10^{-9} m **[e] 9.73×10^{-8} m ***

10. In an electron microscope, electrons are accelerated to great velocities. Calculate the de Broglie **wavelength** of an electron traveling with a velocity of 7.0×10^6 m/s. [mass electron = 9.11×10^{-28} g]

[a] 1.0×10^{-13} m [b] 1.0×10^{-7} m [c] 1.0 m [d] 4.86×10^{-9} m **[e] 1.0×10^{-10} m ***

11. How many **orbitals** are in the 3rd principal energy level, $n = 3$?

[a] 1 [b] 4 **[c] 9 *** [d] 16 [e] 18

12. A possible set of *quantum numbers* for the last electron (outermost electron) in an **iodine** atom, **I**, in its ground state is:

	n	l	m_l	m_s
[a]	5	0	0	–1/2
[b]	5	2	+1	–1/2
[c]	6	1	0	+1/2
[d]*	**5**	**1**	**–1**	**+1/2**
[e]	5	1	+2	+1/2

13. An atom of cadmium, Cd, has ____ unpaired electrons and is _____ .

[a] 0, diamagnetic*[b] 2, paramagnetic [c] 3, paramagnetic [d] 10 diamagnetic [e] 12, diamagnetic

14. A substance is said to be **oxidized** when:

[a] it increases the number of electrons it has.
[b] it loses electrons. *
[c] accepts hydrogen ions and becomes positively charged.
[d] accepts hydroxide ions and becomes negatively charged.
[e] reacts with water.

15. What is the **oxidation number** of each atom in calcium perchlorate, $Ca(ClO_4)_2$?

[a] Ca = +2, Cl = –1, O = –2 [b] Ca = +2, Cl = +1, O = –2 [c] Ca = –2, Cl = –1, O = +2
[d] Ca = +2, Cl = –1, O = 0 **[e] Ca = +2, Cl = +7, O = –2 ***

16. What **mass** of K_2CO_3 is needed to prepare 200.0 mL of a solution with a concentration of 0.150 *M*?
[Molar mass (K_2CO_3) = 138.2 g/mol]

[a] 4.15 g * [b] 104 g [c] 1.84 g [d] 0.0300 g [e] 4150 g

17. If 17.5 mL of a 0.1050 *M* Na_2CO_3 solution is added to 46.0 mL of a 0.1250 *M* NaCl solution, what is the **concentration** of **sodium ion (Na^+)** in the resulting solution? Assume that the volumes are additive.

[a] 0.205 *M* [b] 0.119 *M* [c] 0.539 *M* **[d] 0.148 *M* *** [e] 0.165 *M*

18. If excess sodium hydroxide (NaOH) reacts with **one** mole of phosphoric acid (H_3PO_4), how many **moles** of water are produced?

[a] 0.33 mol [b] 1 mol [c] 2 mol **[d] 3 mol *** [e] 5 mol

19. Given the three statements below, which answer is **correct**?

I) An exothermic reaction releases heat to the surroundings.
II) The sign of ΔH for an exothermic reaction is positive.
III) For an endothermic reaction to be carried out, heat must be supplied from the surroundings.

[a] I and II are true, III is false [b] II and III are true, I is false [c] I, II, and III are true
[d] I, II, and III are false **[e] I and III are true, II is false ***

20. If the same amount of heat is added to 5.00 g samples of the metals listed below, which metal will experience the **smallest temperature change**?

Metal	Specific Heat Capacity (J/g·°C)
Al	0.897
Pb	0.13
Cu	0.385
Fe	0.449
Na	1.21

[a] Al [b] Pb [c] Cu [d] Fe **[e] Na ***

21. Using standard enthalpies of formation, calculate the standard enthalpy of reaction (ΔH°_{rxn}) for making ethanol (C_2H_5OH) form carbon dioxide and water.

$$2\ CO_2\ (g)\ +\ 3\ H_2O\ (g)\ \rightarrow\ C_2H_5OH\ (l)\ +\ 3\ O_2\ (g)$$

$\Delta H_f^\circ\ [CO_2(g)] = -393.5$ kJ/mol, $\Delta H_f^\circ\ [H_2O(l)] = -285.8$ kJ/mol, $\Delta H_f^\circ\ [H_2O(g)] = -241.8$ kJ/mol,
$\Delta H_f^\circ\ [C_2H_5OH(l)] = -276.98$ kJ/mol.

[a] 358.3 kJ **[b] 1235.4 kJ *** [c] 1367.4 kJ [d] +1789.4 kJ [e] −1789.4 kJ

22. Your are given the following thermochemical equations:

$CH_4\ (g)\ +\ 2\ O_2\ (g)\ \rightarrow\ CO_2\ (g)\ +\ 2\ H_2O\ (l)$ $\Delta H_{rxn} = -890$ kJ
$C_2H_4\ (g)\ +\ 3\ O_2\ (g)\ \rightarrow\ 2\ CO_2\ (g)\ +\ 2\ H_2O\ (l)$ $\Delta H_{rxn} = -1410$ kJ

What is the ΔH for the reaction:

$$2\ CH_4\ (g)\ +\ O_2\ (g)\ \rightarrow\ C_2H_4\ (g)\ +\ 2\ H_2O\ (l)$$

[a] −3190 kJ [b] −2300 kJ [c] +520 kJ **[d] −370 kJ *** [e] +2300 kJ

PART III: Problems

23. A coin dealer, offered a rare silver coin, suspected that it might be a counterfeit nickel copy. The dealer heated the coin, which weighed 62.0 g, to 100.0°C in boiling water and then dropped the hot coin into 86.0 g of water at a temperature of 15.5°C in a coffee-cup calorimeter. The final temperature of the water and coin was 21.5°C. Was the coin made of silver or nickel? Assume all the heat from the coin was transferred to the water.
[$s_{H_2O} = 4.184$ J/g·°C, $s_{Ni} = 0.444$ J/g·°C, $s_{Ag} = 0.235$ J/g·°C] **You must show work to receive credit.** [5 pts]

$-q_{coin} = +q_{water}$

$-m_c s_c \Delta t_c = +m_w s_w \Delta t_w$

$-(62.0\text{ g})(s_c)(21.5°\text{C} - 100°\text{C}) = +(86.0\text{ g})(4.184\text{ J/g·°C})(21.5°\text{C} - 15.5°\text{C})$

$(4.87 \times 10^3)s_c = 2.16 \times 10^3$

$s_c = 0.444$ J/g·°C

Based on the specific heat matching that of nickel, the coin was made of **nickel**.

24. The average US household consumes 39.5 GJ (3.95×10^7 kJ) of energy per year. Using the reaction below, how many **grams** of methane (CH_4) must be burned to supply this amount of energy? [4 pts]
[Molar masses: $CH_4 = 16.04$ g/mol, $O_2 = 32.00$ g/mol]

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g) \qquad \Delta H^\circ_{rxn} = -890.4\text{ kJ}$$

$$3.95 \times 10^7\text{ kJ} \times \frac{1\text{ mol } CH_4}{890.4\text{ kJ}} = 4.436 \times 10^4\text{ mol } CH_4$$

$$4.436 \times 10^4\text{ mol } CH_4 \times \frac{16.04\text{ g } CH_4}{1\text{ mol } CH_4} = \mathbf{7.12 \times 10^5\text{ g } CH_4}$$

25. What is the **molarity** of an oxalic acid ($H_2C_2O_4$) solution if it takes 37.55 mL of 0.1245 *M* sodium hydroxide (NaOH) to titrate 20.00 mL of the oxalic acid solution? [6 pts]

$$H_2C_2O_4\,(aq) + 2\,NaOH \rightarrow Na_2C_2O_4\,(aq) + 2\,H_2O\,(l)$$

$$\text{mol NaOH} = \frac{0.1245\ \text{mol NaOH}}{1\ \text{L soln}} \times (37.55 \times 10^{-3}\ \text{L}) = 0.00467\ \text{mol NaOH}$$

$$\text{mol } H_2C_2O_4 = 0.00467\ \text{mol NaOH} \times \frac{1\ \text{mol } H_2C_2O_4}{2\ \text{mol NaOH}} = 0.00234\ \text{mol } H_2C_2O_4$$

$$\text{M} = \frac{\text{mol}}{\text{L}} = \frac{0.00234\ \text{mol } H_2C_2O_4}{20.00 \times 10^{-3}\ \text{L}} = \mathbf{0.117\ M}$$

26. Write both an **electron configuration** and an **orbital diagram** for each of the following. You may use shorthand notation (noble gas core). [9 pts]

[a] Nb

$[Kr]5s^2 4d^3$

[Kr] $\underset{5s^2}{\uparrow\downarrow}$ $\underset{}{\uparrow}$ $\underset{}{\uparrow}$ $\underset{4d^3}{\uparrow}$ _ _

[b] Ge

$[Ar]4s^2 3d^{10} 4p^2$

[Ar] $\underset{4s^2}{\uparrow\downarrow}$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\underset{3d^{10}}{\uparrow\downarrow}$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\underset{}{\uparrow}$ $\underset{4p^2}{\uparrow}$ —

[c] Ra

$[Rn]7s^2$

[Rn] $\underset{7s^2}{\uparrow\downarrow}$

Potentially Useful Information

$q = ms\Delta T$

$c = \lambda\nu$

$c = 3.00 \times 10^{8}$ m/s

$E = h\nu$

$h = 6.626 \times 10^{-34}$ J·s

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{h}{mu}$$

$$E_n = -R_H\left(\frac{1}{n^2}\right)$$

$\Delta E = E_f - E_i$

$1 \text{ Mm} = 1 \times 10^{6}$ m

$\Delta T = T_f - T_i$

$\Delta H^\circ_{rxn} = \sum n\Delta H^\circ_f(\text{products}) - \sum n\Delta H^\circ_f(\text{reactants})$

$1 \text{ g} = 6.022 \times 10^{23}$ amu

Avogadro's number $= 6.022 \times 10^{23}$ particles/mole

$$1 \text{ J} = \frac{1 \text{ kg} \cdot \text{m}^2}{\text{s}^2}$$

$$\Delta E = -R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$R_H = 2.18 \times 10^{-18}$ J

$$\text{Molarity} = \frac{\text{moles solute}}{\text{L of solution}}$$

$M_1V_1 = M_2V_2$