Name Mr. Perfect Date Sp 09

1. If the *n* quantum number of an atomic orbital is equal to 4, what are the possible values of ℓ? What are the possible values of m_ℓ if the quantum number ℓ is equal to 1? (5 pts)

ℓ ranges from 0 to n-1 m_ℓ

0, 1, 2, 3 -1, 0, +1

2. Give the notation (using letter designations for ℓ) for the sub-shells denoted by the following quantum numbers. (10 pts)

a) $n = 3$, $\ell = 2$ b) $n = 2$, $\ell = 0$ c) $n = 2$, $\ell = 1$ d) $n = 4$, $\ell = 3$

3d 2s 2p 4f

3. Balance the following redox reactions by using the half-reaction method. Clearly label the oxidation and reduction step to receive full credit. (20 pts)

a) $ClO_3^- + I^- \rightarrow I_2 + Cl^-$ (acidic)

(Reduction) $6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$

(Oxidation) $3 \times (2I^- \rightarrow I_2 + 2e^-)$

(Overall) $6H^+ + ClO_3^- + 6I^- \rightarrow 3I_2 + Cl^- + 3H_2O$

b) $CrO_4^{2-} + Cu \rightarrow Cr(OH)_3 + Cu(OH)_2$ (basic)

(Reduction) $2 \times (3e^- + 5H^+ + CrO_4^{2-} \rightarrow Cr(OH)_3 + H_2O)$

(Oxidation) $3 \times (2H_2O + Cu \rightarrow Cu(OH)_2 + 2H^+ 2e^-)$

$4OH^- + 4H^+ + 4H_2O + 2CrO_4^{2-} + 3Cu \rightarrow 2Cr(OH)_3 + 3Cu(OH)_2 + 4OH^-$

(Overall) $8H_2O + 2CrO_4^{2-} + 3Cu \rightarrow 2Cr(OH)_3 + 3Cu(OH)_2 + 4OH^-$

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4. An electron has a de Broglie wavelength of 225 nm. What is the speed (velocity) of the electron in m/s? The mass of an electron is 9.11 x 10^{-31} kg. (10 pts)
h = 6.626 x 10^{-34} J s
1 nm = 10^{-9} m

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

225 nm x 1m/10^{9} nm = 2.25 x 10^{-7} m

1 J = kg m^2/s^2

$$v = \frac{h}{m\lambda} = \frac{6.626x10^{-34}\ J\ s}{(9.11x10^{-31}\ kg)(2.25x10^{-7}\ m)} = 3.23x10^{3}\ m/s$$

5. An electron in the n = 7 level of a hydrogen atom relaxes down to a lower energy level, emitting light of 397 nm. What is the final value of n? (15 pts)

R_H = 2.179 x 10^{-18} J h = 6.626 x 10^{-34} Js c = 3.0 x 10^{8} m/s

$$\Delta E = h\upsilon = h\frac{c}{\lambda}$$

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

397 nm x 1 x10^{-9} m/1 nm = 3.97 x 10^{-7} m

$$\Delta E_{photon} = \frac{h\,C}{\lambda} = \frac{(6.626x10^{-34}\ J\ s)(3.0x10^{8}\frac{m}{s})}{3.97x10^{-7}\ m} = 5.01x10^{-19}\ J$$

$\Delta E_{photon} = -\Delta E_{atom} = -$ 5.01 x 10^{-19} J

$$\Delta E = -R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = -5.01x10^{-19}\ J = -2.179x10^{-18}\ J\left(\frac{1}{n_f^2} - \frac{1}{7^2}\right)$$

$$n_f = \sqrt{\frac{1}{0.2503}} \approx 2$$

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6. An experiment shows a 113 mL gas sample has a mass of 0.171 g at a pressure of 721 mmHg and a temperature of 32 °C. Find the molar mass of the gas. (10 pts)

$$M_w = \frac{m}{n} \quad or \quad n = \frac{m}{M_w}$$

PV = nRT

T = 32 + 273 = 305 K

P = 721 mmHg x 1 atm/760 mmHg = 0.9486 atm

$$PV = \frac{m}{M_w}RT \quad or \quad M_w = \frac{m}{V}\frac{RT}{P}$$

$$M_w = \frac{(0.171\ g)}{(0.113\ L)}\frac{\left(0.0821\ \frac{L\ atm}{mol\ K}\right)(305\ K)}{(0.9486\ atm)} = 39.9\ g/mol$$

7. A syringe containing 1.55 mL of oxygen gas is cooled from 95.3 °C to 0.0 °C. What is the final volume of the oxygen gas in the syringe? Assume the pressure remains constant. (5 pts)

T_1 = 95.3 + 273 = 368.3 K
T_2 = 0.0 + 273 = 273 K

$$V_2 = \frac{(1.55\ mL)(273\ K)}{(368.3\ K)} = 1.15\ mL$$

8. What mass of natural gas (CH_4) must you burn to <u>emit</u> 267 kJ of heat? (5 pts)

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)} \quad ; \quad H°_{rxn} = -802.3\ kJ$$

Emits energy (exothermic) = negative sign for energy

$$\frac{16\ g}{mol} \times \frac{mol}{-802.3\ kJ} \times (-267\ kJ) = 5.32\ g$$

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9. Given the following data:

$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$; $\Delta H° = -74.6$ kJ reverse

$C_{(s)} + 2Cl_{2(g)} \rightarrow CCl_{4(g)}$; $\Delta H° = -95.7$ kJ

$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$; $\Delta H° = -92.3$ kJ multiply by 2

Calculate the $\Delta H°_{rxn}$ for the following reaction: (10 pts)

$$CH_{4(g)} + 4Cl_{2(g)} \rightarrow CCl_{4(g)} + 4HCl_{(g)} \qquad \Delta H°_{rxn} = ?$$

	$\Delta H°$
$CH_4 \rightarrow$ ~~C~~ + ~~$2H_2$~~	+ 74.6 kJ
~~C~~ + $2Cl \rightarrow CCl_4$	- 95 kJ
~~$2H_2$~~ + $2Cl_2 \rightarrow 4HCl$	-184.6 kJ
$CH_{4(g)} + 4Cl_{2(g)} \rightarrow CCl_{4(g)} + 4HCl_{(g)}$	-205.7 kJ

10. Suppose that a 25 g sample of iron is initially at 35.0 °C. What is the final temperature of the sample after releasing 14.8 J of heat? (10 pts)
Cs or S = 0.449 J/g °C

$$Q = m \times S \times \Delta T$$

Releasing energy = exothermic (negative sign)

$$-14.8 \text{ J} = 25 \text{ g} \times 0.449 \text{ J/g °C} \times (T_f - 35.0 \text{ °C})$$

$$T_f = 33.7 \text{ °C}$$

11. (Extra Credit) Draw the shapes of the p-orbitals and include axis labels. (5 pts)