Name _____Mr. Perfect_____ Date __F 11_____

1. If the *n* quantum number of an atomic orbital is equal to 2, what are the possible values of ℓ ? What are the possible values of m_ℓ if the quantum number ℓ is equal to 3? (5 pts)

ℓ ranges from 0 to n-1 m_ℓ

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

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

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

2s 3d 4f 1s

3. Write both the electron configurations and the orbital diagrams for the following elements in their ground states. Also, state if the element is paramagnetic or diamagnetic. (20 pts)

a) $_{35}$Br

[Ar] $4s^2 3d^{10} 4p^5$

[Ar] [↑↓] [↑↓][↑↓][↑↓][↑↓][↑↓] [↑↓][↑↓][↑] Paramagnetic
4s 3d 4p

b) $_{4}$Be

$1s^2 2s^2$

[↑↓] [↑↓] Diamagnetic
1s 2s

c) $_{14}$Si

[Ne] $3s^2 3p^2$

[Ne] [↑↓] [↑][↑][ ] Paramagnetic
3s 3p

d) $_{10}$Ne
$1s^2 2s^2 2p^6$

[↑↓] [↑↓] [↑↓][↑↓][↑↓] Diamagnetic
1s 2s 2p

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4. Use the Rydberg equation to calculate the wavelength (in nm) of a photon when a hydrogen atom undergoes a transition from n = 3 to n = 5. Clearly state if light was absorbed or emitted in this transition. Would this transition occur in the infrared or ultraviolet region of the electromagnetic spectrum? R = 1.0967 x 10^7 m^{-1} (15 pts)

$$\frac{1}{\lambda} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})$$

$n_2 > n_1$

$$\frac{1}{\lambda} = 1.0967\ x\ 10^7\ m^{-1}\left(\frac{1}{3^2} - \frac{1}{5^2}\right) = 1.0967\ x\ 10^7\ m^{-1}(0.111 - 0.040)$$

$$\frac{1}{\lambda} = 778657\ m^{-1}$$

$$\lambda = 1.28\ x\ 10^{-6} m\ \times \frac{10^9 nm}{1\ m} = \mathbf{1284\ nm} \quad Infrared\ region$$

Light was absorbed

5. If ΔE for an electronic transition in a hydrogen atom is –3.029 x 10^{-19} J, find n_f if n_i = 3. R_H = 2.179 x 10^{-18} J (10 pts)

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

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

$$-3.029\ x10^{-19}\ J = -2.179x10^{-18}\ J\left(\frac{1}{n_f^2} - \frac{1}{3^2}\right)$$

$$n_f = \sqrt{\frac{1}{0.2501}} \approx \mathbf{2}$$

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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)

R = 0.0821 L atm/mol K

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

PV = nRT

T = 32 + 273 = 305 K

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

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

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

What volume will one mole of the above gas mixture occupy at STP? (5 pts)

STP (Standard Temperature and Pressure) 1 atm and 0 °C (273 K)

$$v = \frac{nRT}{P} = \frac{(1\ mol)\left(0.0821\frac{Latm}{mol\ K}\right)(273\ K)}{1\ atm} = \mathbf{22.4\ L}$$

7. Mothballs are composed primarily of the hydrocarbon naphthalene ($C_{10}H_8$). When 1.025 g of naphthalene is burned in a bomb calorimeter, the temperature of the calorimeter rises from 24.25 °C to 32.33 °C. Find ΔE_{rxn} (kJ/mol) for the combustion of naphthalene. The heat capacity of the calorimeter is 5.86 kJ/ °C. (10 pts)

$$Q_{cal} = C_{cal}\ \Delta T$$

Q_{cal} = 5.86 kJ/°C(32.33 °C – 24.25 °C) = 47.3 kJ

$Q_{cal} = - Q_{rxn}$

Q_{rxn} = -47.3 kJ

1.025 g x 1mol/128g = 8.01 x 10^{-3} mol

$$\Delta E_{rxn} = \frac{-47.3\ \text{kJ}}{8.01\ \text{x}\ 10^{-3}} = \mathbf{-5911\ kJ/mol}$$

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8. Given the following data:

Reverse $2O_{3(g)} \rightarrow 3O_{2(g)}$; $\Delta H° = -427$ kJ

2 x $NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$; $\Delta H° = -199$ kJ

Reverse $O_{2(g)} \rightarrow 2O_{(g)}$; $\Delta H° = 495$ kJ

Calculate the $\Delta H°$ for the following reaction: (10 pts)

$NO_{(g)} + O_{(g)} \rightarrow NO_{2(g)}$ $\Delta H° = ?$

~~$3O_{2(g)} \rightarrow 2O_{3(g)}$~~ 427 kJ

$2NO_{(g)} + $ ~~$2O_{3(g)}$~~ $\rightarrow 2NO_{2(g)} +$ ~~$2O_{2(g)}$~~ -398 kJ

~~$2O_{(g)} \rightarrow O_{2(g)}$~~ -495 kJ

$2NO_{(g)} + 2O_{(g)} \rightarrow 2NO_{2(g)}$ -466 kJ

$NO_{(g)} + O_{(g)} \rightarrow NO_{2(g)}$ $\Delta H° =$ **-233 kJ**

9. Balance the following redox reaction in basic media and clearly label the oxidation and reduction steps. (5 pts)

$$Bi(OH)_3 + SnO_2^{2-} \rightarrow SnO_3^{2-} + Bi$$

$2 \times (3e^- + 3H^+ + Bi(OH)_3 \rightarrow Bi + 3H_2O)$ reduction

$3 \times (H_2O + SnO_2^{2-} \rightarrow SnO_3^{2-} + 2H^+ + 2e^-)$ oxidation

~~$6H^+$~~ $+ 2Bi(OH)_3 +$ ~~$3H_2O$~~ $+ 3SnO_2^{2-} \rightarrow 2Bi +$ ~~$6H_2O$~~ $+ 3SnO_3^{2-} +$ ~~$6H^+$~~

$$2Bi(OH)_3 + 3SnO_2^{2-} \rightarrow 2Bi + 3H_2O + 3SnO_3^{2-}$$

10. (Extra Credit) A system releases 415 kJ of heat and does 125 kJ of work on the surroundings. What is the change in internal energy of the system? (5 pts)

$\Delta E = q + w = (-415 \text{ kJ}) + (-125 \text{ kJ}) =$ **-540 kJ**