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ANSWER KEY

CHEMISTRY F14O4 SECOND EXAM 3/22/00
PROFESSOR J. MORROW

PRINT NAME, LAST: ____________________________

FIRST: ____________________________

I.D.# : ____________________________

MAXIMUM POINT VALUE IS IN PARENTHESES

1. ________ (20)	8. ________ (8)	15. ________ (8)
2. ________ (20)	9. ________ (8)	16. ________ (8)
3. ________ (20)	10. ________ (8)	17. ________ (8)
4. ________ (20)	11. ________ (8)	18. ________ (8)
5. ________ (20)	12. ________ (8)	19. ________ (8)
6. ________ (20)	13. ________ (8)	20. ________ (8)
7. ________ (20)	14. ________ (8)	21. ________ (8)

COLUMN TOTALS (MAXIMUM):

________(100)	________(56)	________(56)

EXAM TOTAL (188 pts) ___________ ___________
OUT OF 1OO

1) Hydrogen atoms are excited from n = 1 —> n =2. The electron in the n = 2 shell then returns to n = 1 emitting a photon. These emitted photons hit a piece of copper (work function, Φ = 2.40 eV = $3.85\text{x}10^{-19}$J) causing electrons to be ejected. Calculate the energy of these ejected electrons in joules. SHOW WORK (20 pts)

a) $1.63\text{x}10^{-18}$J b) $0.384\text{x}10^{-18}$J c) $2.18\text{x}10^{-18}$J d) $0.161\text{x}10^{-18}$J e) $1.25\text{x}10^{-18}$J

$$\varepsilon_{photon} = 2.179\text{x}10^{-18}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 2.179\text{x}10^{-18}\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 1.634\text{x}10^{-18}\text{J}$$

$$\varepsilon = h\nu - \Phi = \varepsilon_{photon} - \Phi = 1.634\text{x}10^{-18}\text{J} - (2.40\text{eV})(1.6022\text{x}10^{-19}\frac{\text{J}}{\text{eV}})$$

$$\varepsilon = 12.5\text{x}10^{-19}\text{J} = 1.25\text{x}10^{-18}\text{J}$$

ANSWER IS: <u>e</u>

2) A typical golf ball weighs 40.0 g. If it is moving with a velocity of 20.0 $\frac{\text{m}}{\text{sec}}$, its deBroglie wavelength is , (20 pts)

a) $1.66\text{x}10^{-34}$nm b) $8.28\text{x}10^{-32}$nm c) $8.28\text{x}10^{-25}$nm
d) $1.66\text{x}10^{-24}$nm e) $3.31\text{x}10^{-21}$nm

m = 40.0 g = 0.0400 kg v = 20.0 $\frac{\text{m}}{\text{sec}}$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{6.626\text{x}10^{-34}}{(0.0400)(20.0)} = 8.28\text{x}10^{-34}\text{ m}$$

$$\lambda = 8.28\text{x}10^{-34}\text{ m} = 8.28\text{x}10^{-25}\text{ nm}$$

ANSWER IS: <u>c</u>

3) According to quantum mechanics, the energy of a particle in a 1 dimensional box is, $\varepsilon_n = \frac{n^2h^2}{8m\lambda^2}$

where n is the quantum number, h is Planck's constant, m is the mass of the particle, and λ is the length of the box. This is the equation that allows us to predict the color of dyes.

What is the wavelength (in nm) of photon required to excite an electron from n = 1 to n = 2 in a box of λ = 5.0 Å ? SHOW WORK (20 pts)

a) 1236 nm b) 618 nm c) 412 nm d) 332 nm e) 206 nm f) 824 nm

$$\varepsilon = \frac{n^2h^2}{8m\lambda^2} = h\nu = \frac{hc}{\lambda}$$

$$\lambda = (\frac{1}{1^2} - \frac{1}{2^2})(\frac{8m\lambda^2 c}{h}) = (\frac{3}{4})\ \frac{(8)(9.108\text{x}10^{-31})(5.0\text{x}10^{-10})^2(3.0\text{x}10^8)}{6.626\text{x}10^{-34}}$$

$$\lambda = 618 \text{ nm}$$

ANSWER IS: <u>b</u>

4) The kinetic energy, ε, of a electron is related to the kelvin temperature through the equation, $\varepsilon = \frac{3}{2}\ kT$ where $k = 1.38\text{x}10^{-23}\ \frac{J}{\text{particle}\cdot\text{degK}}$.

You are given an electron with a deBroglie wavelength of λ = 76.3 nm . What is the Kelvin temperature of this electron? SHOW WORK (20 pts)

a) 0.50 b) 1.00 c) 1.50 d) 2.00 e) 2.50 f) 3.00

$$\lambda = \frac{h}{p} \quad \text{and} \quad \frac{p^2}{2m} = \varepsilon = \frac{3}{2}\ kT \quad \therefore\ p = (3mkT)^{1/2}$$

$$\lambda = \frac{h}{p} = \frac{h}{(3kmT)^{1/2}} \quad \therefore \quad T = \frac{h^2}{3km\lambda^2}$$

$$T = \frac{h^2}{3k\lambda^2} = \frac{(6.626\text{x}10^{-34})^2}{(3)(1.38\text{x}10^{-23})(9.108\text{x}10^{-31})(76.3\text{x}10^{-9})^2} = 2.00 \text{ K}$$

$$T = 2.00 \text{ K}$$

ANSWER IS: <u>d</u>

5) When the surface of a piece of potassium is irradiated with light of wavelength, λ_1 = 5000 Å, the value of the stopping potential (voltage) necessary to stop the emitted electrons is, V_1 = 0.200 volts. When the wavelength is changed to, λ_2 = 4000 Å, the required stopping potential is,

V_2 = 0.600 volts. In this problem, YOU DO NOT KNOW the value of Planck's constant. Using this information calculate Planck's constant. SHOW WORK
(20 pts)

a) $4.27x10^{-34}$ b) $3.60x10^{-34}$ c) $2.14x10^{-34}$
d) $7.48x10^{-34}$ e) $1.57x10^{-34}$ f) $6.63x10^{-34}$

$$\varepsilon = qV = h\nu - \Phi = \frac{hc}{\lambda} - \Phi \qquad \therefore \quad V = \frac{hc}{\lambda q} - \frac{\Phi}{q}$$

$$V_2 = \frac{hc}{\lambda_2 q} - \frac{\Phi}{q} \quad \text{and} \quad V_1 = \frac{hc}{\lambda_1 q} - \frac{\Phi}{q}$$

$$\therefore \quad V_2 - V_1 = \left(\frac{hc}{q}\right)\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$$

$$\therefore \quad h = \frac{(V_2 - V_1)q}{\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)c} = \frac{(0.600 - 0.200)(1.6022x10^{-19})}{\left(\frac{1}{4.00x10^{-7}} - \frac{1}{5.00x10^{-7}}\right)(3.0x10^{8})}$$

$$h = 4.27x10^{-34} \text{ J·sec}$$

(20 pts) ANSWER IS: a

6) Using any information from question 5 and your calculated value of planck's constant (also from question 5), calculate the work function, Φ, of potassium in electron volts (eV). If you did not do question 5 but want to answer this question, use h = $6.63x10^{-34}$ J·sec SHOW WORK (20 pts)

a) 1.40 eV b) 1.08 eV c) 0.40 eV
d) 2.90 eV e) 0.13 eV f) 2.50 eV

SAMPLE CALCULATION USING THE CORRECT ANSWE R FROM QUESTION 5.

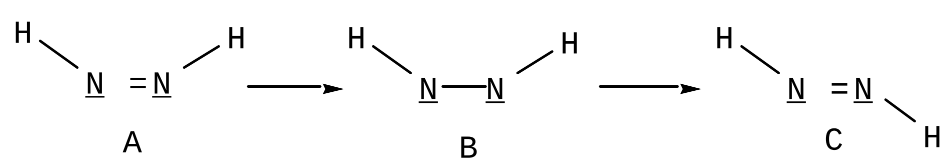
$$\Phi(\text{in eV}) = \frac{hc}{\lambda q} - V = \frac{(4.27x10^{-34})(3.0x10^{8})}{(4.00x10^{-7})(1.602x10^{-19})} - 0.600$$

$$\Phi(\text{in eV}) = 1.40 \text{ eV}$$

ANSWER IS: _______

7) Given the following bond enthalpies,

N=N (711 kJ/mol) and N - N (163 kJ/mol)



Molecule A has the above configuration. To make it have the configuration of molecule C, the π bond in molecule A must be broken thereby forming molecule B where rotation around the N to N single bond occurs. The π bond then reforms giving you molecule C. What is the wavelength of light, λ (in nm), required to initiate this process?SHOW WORK (20 pts)

a) 168 nm b) 733 nm c) 310 nm d) 218 nm e) 425nm

Energy required = 711 - 163 = 548 kJ/mol

$$\varepsilon = (548 \frac{kJ}{mol})(10^3 \frac{J}{kJ})(\frac{1}{6.022x10^{23}} \frac{mol}{molecule}) = 9.10x10^{-19} J$$

$$\varepsilon = \frac{hc}{\lambda} \quad \text{AND} \quad \lambda = \frac{hc}{\varepsilon}$$

$$\lambda = \frac{hc}{\varepsilon} = \frac{(6.626x10^{-34})(3x10^{8})}{9.10x10^{-19}} = 2.18x10^{-7} m = 218 \text{ nm}$$

GIVE 12 pts FOR EITHER a or b. ANSWER IS: d

8) Which of the following molecules would have the shortest bond length? All have single bonds. (8 pts)

a) Na_2 b) F_2 c) Li_2 d) Cl_2

ANSWER IS: b

9) Which of the following ions has the largest radius? (8 pts)

a) Be^{2+} b) Li^{+} c) N^{3-} d) O^{2-} e) F^{-}

ANSWER IS: c

10) The order of increasing ionization energies for the atoms neon, nitrogen, phosphorus, and sodium is; (8 pts)

a) Na < P < N < Ne b) N < Ne < Na < P c) N < Na < Ne < P

d) Na < N < P < Ne e) N < Na < P < Ne

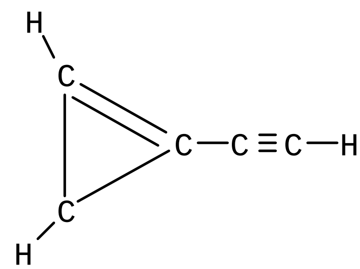
ANSWER IS: a

11) A beam of incoming cosmic radiation has a wave number,
ν (nu bar) = $2.5x10^4 \frac{1}{cm}$.
Calculate the wavelength of this radiation (in nm). (8 pts)

a) 650 nm b) 125 nm c) 250 nm d) 400 nm e) 350 nm

ANSWER IS: d

12) Given the following molecule;



This molecule contains the following number of σ and π bonds

a) four π bonds and six σ bonds
b) seven σ bonds and three π bonds
c) six σ bonds and four π bonds
d) two π bonds and eight σ bonds
e) three π bonds and eight σ bonds
f) none of the above
(8 pts)

ANSWER IS: e

13) Which of these molecules is/are nonpolar ; IF_3 , BF_3 , NF_3 , CF_4 , and, SF_4 (8 pts)

ANSWER: BF_3 and CF_4

14) Circle the stronger acid in each of the following pairs. (8 pts)

a) ***H_2SO_3*** or H_2SeO_3 (4 pts)

b) H_2SO_4 or ***$H_2S_2O_7$*** (4 pts)

15) Give the electronic configuration ($1s^2$ etc) <u>and</u> the number of unpaired electrons in each of the following gaseous atoms/ions.
Atomic number of nickel is 28. UE = number of unpaired electrons. (4 pts each: 3 pts plus 1 pt)

Ni $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ OR $[Ar]4s^2 3d^8$ UE = 2

Ni^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$ OR $[Ar]3d^7$ UE = 3

16) List the following ions in order of decreasing ionic radius.
Li^{2+}, Be^{2+}, and B^{2+} (8 pts)

$B^{2+} > Li^{2+} > Be^{2+}$

17) List the following atoms in order of increasing 2nd ionization energy: O, F, and S. (8 pts)

$S < O < F$

18) Which atom has the following successive values of ionization energy, IE, (in kJ/mol)? (8 pts)

IE_1 = 575, IE_2 = 1,811 , IE_3 = 2,733 , IE_4 = 11,548 , IE_5 = 14,800

a) N b) Mg c) C d) Na e) Al

ANSWER IS: <u>e</u>

19) Match up the following bond enthalies (in kJ/mol), 514, 837, 949, 1076 with the indicated molecules; (8 pts)

N+N <u>949</u> C+C <u>837</u> C+O <u>1076</u> P+P <u>514</u>

20) In a multi-electron atom, how many electrons can have the following sets of quantum numbers? (8 pts - 2 pts each)

a) $n = 2,\ m_\lambda = -2,\ m_s = -\frac{1}{2}$ <u>0</u>

b) $n = 4,\ m_s = +\frac{1}{2}$ <u>16</u>

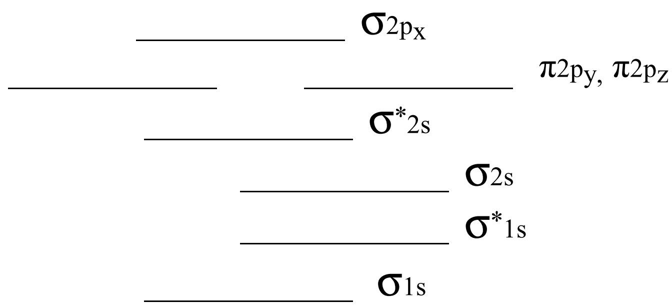
c) $n = 3,\ m_\lambda = 0,\ m_s = -\frac{1}{2}$ <u>3</u>

d) $n = 3,\ \lambda = 2,\ m_s = -\frac{1}{2}$ <u>5</u>

21) Use the MO correlation diagram below to answer this question.

______________ σ^*2p_x

______________ ______________ π^*2p_y, π^*2p_z



Compare the anticipated bond order (BO), bond length (BL), and bond enthalpy (BE) of the following species. Where possible, give the numerical value, otherwise use <, or =, or >.

a) B_2^+ with F_2^- (6 pts)

	B_2^+		F_2^-
BO	0.5		0.5
BL		>	
BE		<	

b) Will the following reaction be exothermic or endothermic?

(2 pts) $O_2^+ + O \longrightarrow O_2 + O^+$

BO 2.5 ... 2.0

ANSWER: endo