Recitation Worksheet (Optional Extra Practice)

Name: Key UGA ID:

Textbook:
Chemistry & Chemical Reactivity
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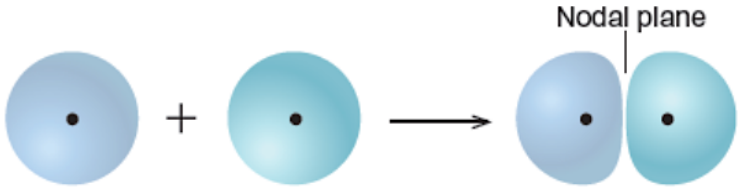
Instructions:
- This recitation worksheet is optional extra practice for Ch. 9.2.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- A periodic table and formula sheet are attached to the end of this worksheet.

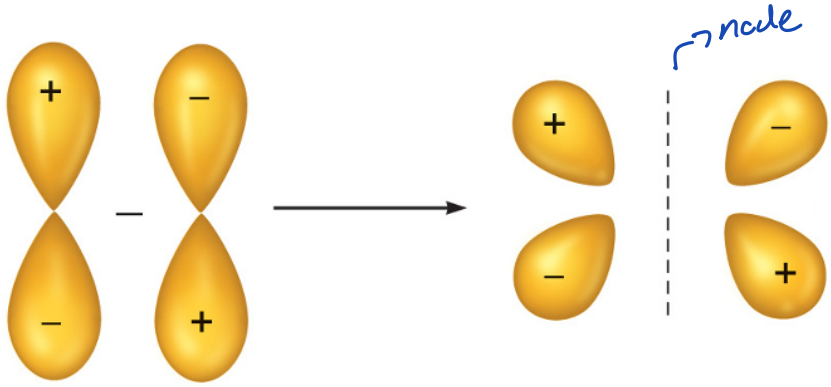
1. Consider the illustration below showing the overlap of two s orbitals resulting in a molecular orbital. Which of the following statements below are **true**?



B

A. The orbital is a σ molecular orbital
B. The orbital is a σ* molecular orbital
C. The orbital is a π molecular orbital
D. The orbital is a π* molecular orbital
E. None of the above are true

2. Consider the illustration below showing the overlap of two p orbitals resulting in a molecular orbital. Which of the following statements below are **true**?

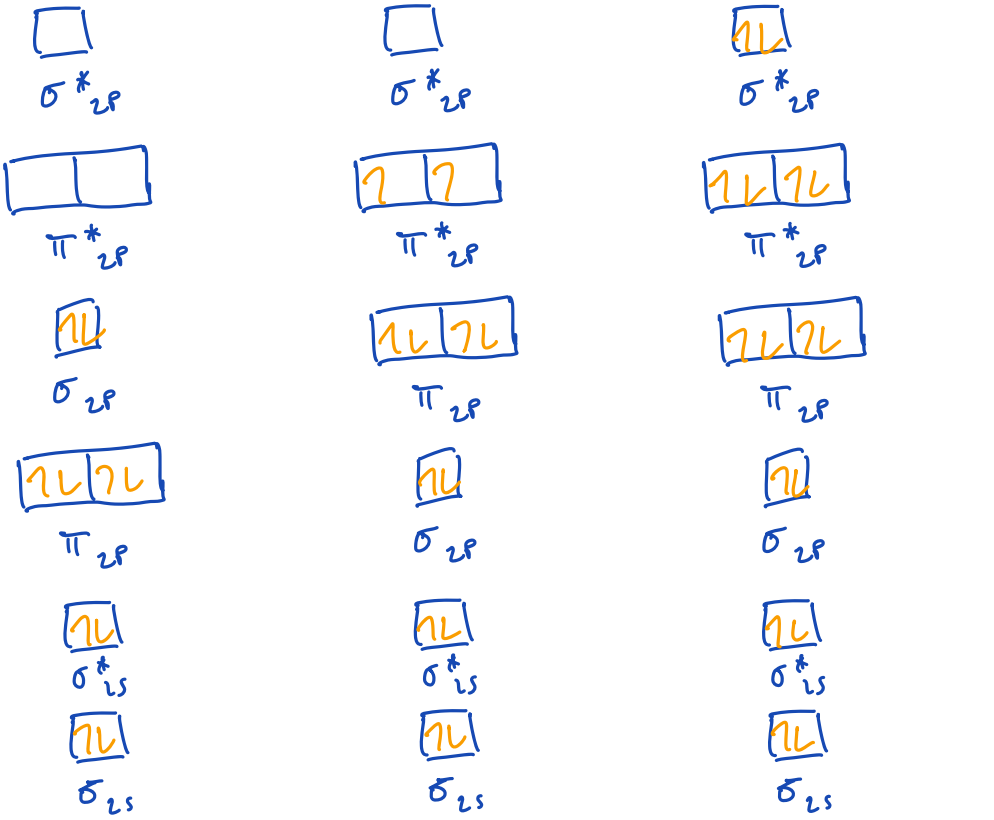


D

A. The orbital is a σ molecular orbital
B. The orbital is a σ* molecular orbital
C. The orbital is a π molecular orbital
D. The orbital is a π* molecular orbital
E. None of the above are true

↳ s-p mixing!

Draw MO diagrams for the ions C_2^{2-}, F_2^{2+}, F_2^{2-} and answer questions 3-8 starting on the next page. The area below has been left blank to draw your diagrams if needed.



C_2^{2-} ↳ 10 valence e's

F_2^{2+} ↳ 12 valence e's

F_2^{2-} ↳ 16 valence e's

3. What is the bond order for each of these ions? Answer with an integer or a decimal to two decimal places (e.g. 2, 0.75).

I. C_2^{2-} [3] $\frac{8-2}{2} = 3$

II. F_2^{2+} [2] $\frac{8-4}{2} = 2$

III. F_2^{2-} [0] $\frac{8-8}{2} = 0$

4. Which of the following ions is unstable?

[C]

A. C_2^{2-}
B. F_2^{2+}
C. F_2^{2-} → B.O. = 0
D. All of the above are stable

5. Which of the following ions would become less stable if an electron is added? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

[AB]

A. C_2^{2-} → add to an antibonding MO
B. F_2^{2+}
C. F_2^{2-}
D. None of the above

6. Which of the following ions is/are predicted to be diamagnetic?

D

A. C_2^{2-}
B. F_2^{2+}
C. F_2^{2-}
D. More than one of the above (C_2^{2-} and F_2^{2-})
E. None of the above

7. What is the highest occupied molecular orbital (HOMO) in the C_2^{2-} ion?

C

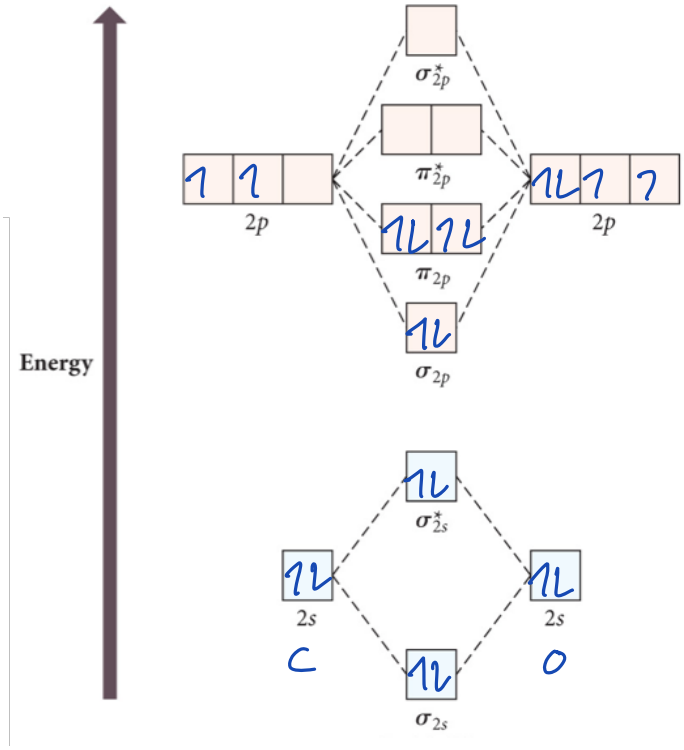
A. σ_{2s}
B. σ^*_{2s}
C. σ_{2p}
D. σ^*_{2p}
E. π_{2p}
F. π^*_{2p}

8. What is the lowest unoccupied molecular orbital (LUMO) in the C_2^{2-} ion?

F

A. σ_{2s}
B. σ^*_{2s}
C. σ_{2p}
D. σ^*_{2p}
E. π_{2p}
F. π^*_{2p}

Draw the Lewis structure for CO. Afterwards, fill in the MO diagram provided below as your model for CO, and then answer questions 9-11.



9. What is the bond order for CO based on its **Lewis structure**? Answer with an integer or a decimal to two decimal places (e.g. 2, 0.75).

3

:C≡O:

10. What is the bond order for CO based on its **MO diagram**? Answer with an integer or a decimal to two decimal places (e.g. 2, 0.75).

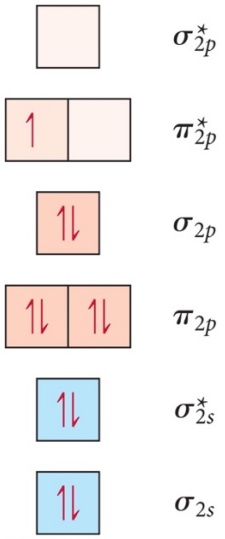
3

$\frac{8-2}{2} = 3$

11. Based on your answers, do the Lewis model and the MO model agree with each other regarding the bond order for CO?

A. Yes
B. No
C. A conclusion cannot be drawn

Answer questions 12-14 using the molecular orbital diagram of an unknown molecule given below.



12. What is the molecule's bond order? Answer with an integer or fractional number (e.g. 7 or 4.5).

2.5

$\frac{8-3}{2} = 2.5$

13. Is this molecule paramagnetic or diamagnetic?

A

A. Paramagnetic (unpaired e^- present)
B. Diamagnetic
C. There is not enough information to determine this

14. Will removing an electron make the molecule more or less stable?

A

↳ removing an e^- from an antibonding MO

A. More stable
B. Less stable
C. There is not enough information to determine this

Periodic Table of the Elements

1																	18
1 H 1.01	2											13	14	15	16	17	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Cs 132.91	56 Ba 137.33		72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]		104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [269]	109 Mt [277]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 kg·m^2/s^2
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 kg/m·s^2
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} J·sec
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109 x 10^{-31} kg
Mass of a proton: 1.673 x 10^{-27} kg
RH = 2.18 x 10^{-18} J
Specific heat of water = 4.184 J/g·K
Avogadro's number: 6.022×10^{23}
F = 96485 J/(V·mol e$^-$)
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$k_b = 1.381 \times 10^{-23}$ J/K

Equations
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution} = P_{solvent}\ X_{solvent}$
$P_{solution} = \sum P_j = \sum P_j X_j$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$\Delta S = q_{rev}/T$
$\Delta G = \Delta G° + RT \cdot \ln Q$
$R = 8.314$ J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{E_a}{R}(\frac{1}{T_2} - \frac{1}{T_1})$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H^\circ_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$