Problem Set 3

① Answer in your own words why e^- might be best thought of as waves? What experiments would you propose should be made to test this hypothesis?

② i) Express as a single complex number (a) $\frac{5+2i}{3-4i}$ (b) $(7+2i)(6-3i)^2$

ii) Let $\alpha = re^{i\theta}$ & $\beta = Re^{i\phi}$ where r, R, θ & ϕ are real numbers. Show $\alpha\beta = (rR)e^{i(\theta+\phi)}$. Draw a picture using the horizontal real axis, the vertical imaginary axis where α, β & $\alpha\beta$ are drawn.

iii) α^* is the complex conjugate of α. If $\alpha = re^{i\theta}$ what is α^* as a function of r & θ?

iv) Find the value of r & θ for the complex numbers: $1, -1, i, -i, 1+i, -1-i$.

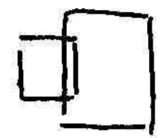
③ Which of the following diatomic molecules is paramagnetic?
(a) HB (b) HC (c.) N_2 (d) O_2 (e) F_2

④ Excercise 1 on page IX.2

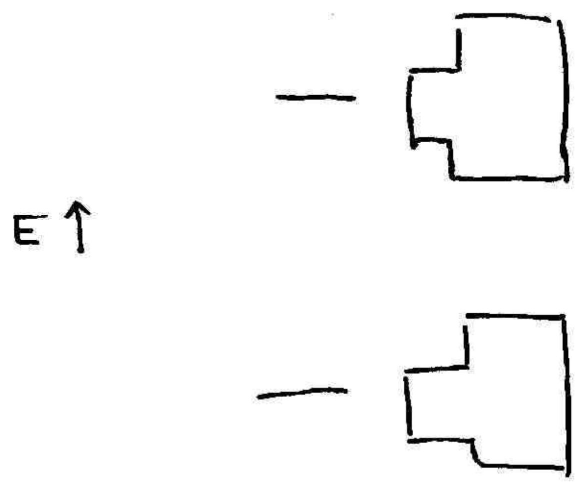
⑤ Let us make a Chladni plate analog for the HF problem. Let us consider a single square plate to represent H and a single square plate to represent F, but let the two plates have different size.

(i) Should the larger square plate be H or F?

(ii) Draw the lowest energy resonance modes of both the small & large plates.

(iii) Overlap the two plates slightly 

Draw in the two lowest in energy resonance modes of the combined plates



Will the lower energy mode be mainly located on the big square or little square plate? Where do you think the higher energy mode (of the two) will be mainly located? Explain how this picture has an analogy in the HF MO diagram.

⑥ (Supplement Problem) In class we found the equation for a wave is

$$\psi = e^{i(kx-\omega t)}$$

$k \propto p$ (momentum) & $\omega \propto E$ (energy)

$$k = \frac{p}{\hbar} \qquad \omega = E/\hbar$$

(they have the same proportionality constants!

$$\therefore \psi = e^{i/\hbar(px - Et)}$$

Show $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\Big|_{\text{constant } t}\psi = -i\hbar\frac{d}{dt}\Big|_{\text{constant } x}\psi = E\psi$ [Schrödinger's equation]

⑦ (i) Use the arguments (qualitative) given in class to guess how the electronegativity runs for the main group elements:

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca	Ga	Ge	As	Se	Br
Rb	Sr	In	Sn	Sb	Te	I
Cs	Ba	Tl	Pb	Bi	(Po)	(At)

(Po), (At): radioactive

(ii) For the transition metals & noble metals, one of the things which happens to the atoms is that the valence s orbitals contract (become more core-like) for the heaviest elements Au & Hg. Would such a contraction make Au or Hg more electronegative or less electronegative (assume the highest energy orbital filled in Au or Hg is the valence s orbital)? Compare your guess with the Pauling electronegativity of these atoms vs. Cu or Zn.