Please answer all questions, showing all calculations

1. Which of the following could be valid wavefunction in the region 0 to infinity? (5 points)
   A) $A \sin^2 kx$
   B) $A e^{kx}$
   C) $A \sin^2 x e^{-kx}$
   D) $A e^{-kx} / \sin x$
   E) $A x e^{-x}$

2. Which of the following excited state wavefunctions are allowed under the Pauli principle for a He–H molecule where $\alpha(n)$ and $\beta(n)$ refer to spin wavefunctions for the nth electron and $\sigma_1(n)$ and $\sigma_2(n)$ refer to molecular orbit wavefunctions constructed from 1s and 2s orbits on the H and He atoms? (15 points)
   A) $\sigma_1(2) \{ \beta(2) - \alpha(2) \} \{ \sigma_1(1) \sigma_2(3) \alpha(1) \beta(3) - \sigma_1(1) \sigma_1(3) \beta(1) \alpha(3) \}$
   B) $\{ \sigma_1(1) \sigma_1(3) \sigma_2(2) - \sigma_1(2) \sigma_2(3) \sigma_1(1) \} \beta(1) \beta(2) \beta(3) +
       \sigma_1(1) \sigma_1(2) \sigma_1(3) \{ \beta(2) \alpha(1) \beta(3) - \beta(1) \beta(1) \beta(2) \alpha(2) \} +
       \sigma_1(2) \sigma_1(3) \sigma_2(1) \alpha(2) \beta(1) \alpha(3) - \sigma_1(1) \sigma_1(3) \sigma_2(2) \alpha(3) \alpha(1) \beta(2)$
   C) $\{ \sigma_1(1) \sigma_1(2) \sigma_2(3) - \sigma_1(3) \sigma_2(1) \sigma_1(2) \} \alpha(1) \beta(2) \alpha(3) +
       \{ \sigma_2(1) \sigma_2(3) \sigma_1(1) - \sigma_1(1) \sigma_2(2) \sigma_1(3) \} \alpha(1) \alpha(2) \beta(3) +
       \{ \sigma_1(2) \sigma_1(1) \alpha(2) - \sigma_1(2) \sigma_1(3) \sigma_2(1) \} \alpha(3) \beta(1) \alpha(2)$
   D) $\{ \sigma_1(1) \sigma_1(2) \sigma_2(3) + \sigma_1(3) \sigma_2(1) \sigma_1(2) \} \alpha(1) \beta(2) \alpha(3) -
       \{ \sigma_1(2) \sigma_2(1) \sigma_1(3) - \sigma_1(1) \sigma_2(2) \sigma_1(3) \} \alpha(1) \alpha(2) \beta(3) +
       \{ \sigma_1(3) \sigma_1(1) \alpha(2) + \sigma_1(2) \sigma_1(1) \sigma_2(3) \} \alpha(3) \beta(1) \alpha(2)$
   E) $\sigma_1(1) \sigma_1(2) \sigma_2(3) \alpha(1) \beta(2) \alpha(3)$

3. What is the bond order for a CF$^-$ molecule? (5 points)
   A) 0
   B) 1
   C) 1.5
   D) 2
   E) 2.5

4. Describe in your own words the Born-Oppenheimer approximation. (12 points)

5. Write the Hückel matrix for the cycloheptatriene carboanion (C$_7$H$_7^-$, negative charge on one carbon). Calculate (using Maple) the 7 energy levels (in terms of $\alpha$ and $\beta$, usual definitions) which constitute the $\pi$ bonding system and indicate lowest energy transition. (15 points)

6. Calculate the absorbance at 550 nm from a solution prepared by mixing 10 ml of 3M CuSO$_4$ with 10 ml of 2M FeSO$_4$ and diluted to 100 ml in a 1.0 cm pathlength cell given the molar absorptivity at 550 nm is $\varepsilon_{Cu} = 2300$ M$^{-1}$ cm$^{-1}$ and $\varepsilon_{Fe} = 7100$ M$^{-1}$ cm$^{-1}$. (10 points)

7. Assuming that the dipole moment operator is just $\mu_x = e\mathbf{x}$, calculate the x component of the transition dipole moment from the n = 1 to the n = K level in the one-dimensional particle in a box. What transitions will be allowed? (10 points, use Maple to perform required integral.)