Multiple Choice Questions   **Circle one answer** for each question (5 points each, 40 total)

1) Which of the following types of radiation has the highest energy?

   A) radio waves   **B)** microwaves   **C)** X-ray

   D) visible   **E)** infrared   **F)** ultraviolet

2) The sun's surface temperature is 5780 K. Which star would appear red?

   A) Rigel A – 12140 K   **B)** Epsilon Indi – 4130 K   **C)** Vega – 9900 K

   D) YZ Ceti – 2670 K   **E)** Capella – 5150 K

3) Arrange the following elements in order of increasing electronegativity: C, F, Na, O

   A) C, O, F, Na   **B)** Na, O, C, F   **C)** Na, C, F, O

   D) Na, C, O, F   **E)** F, O, C, Na

4) A full quantum calculation of electronic structure indicates that the dipole moment of PH_3 is zero. Which statement(s) best explains this result?

   A) PH_3 is a trigonal planar structure and the bond dipoles cancel.
   B) PH_3 violates the octet rule and does not exist.
   C) The electronegativities of P and H are very close in value; therefore, no bond dipoles exist.
   D) **A** and **C** only
   E) **A, B,** and **C**

5) According to the Bohr model of the atom, which state is the *most weakly bound* (highest in energy)?

   A) $n = 1$ electron in He^+
   B) $n = 2$ electron in H
   C) $n = 2$ electron in He^+
   D) $n = 3$ electron in Li^{2+}
   E) $n = 3$ electron in H

6) The uncertainty in the velocity of an electron is 1×10^5 m s^{-1}. What is the minimum uncertainty in its position?

   A) 5.79×10^{-5} m
   B) 2.31×10^{-9} m
   C) 5.79×10^{-10} m
   D) 2.31×10^{-10} m
   E) 1.08×10^{-10} m

A

7) In the photoelectric effect, increasing the intensity of the light will:

    A) ensure that electrons will be emitted from all metals.
    B) cause more electrons to be emitted from the metal if the frequency is sufficiently high.
    C) cause the electrons to be emitted with higher kinetic energy if the frequency is sufficiently high.
    D) have no effect on the experiment.
    E) both **b** and **c**

8) Which plot corresponds to Ψ^2 of 1-D particle in a box for $n = 3$?

A)

B)

C)

D)

E)

A
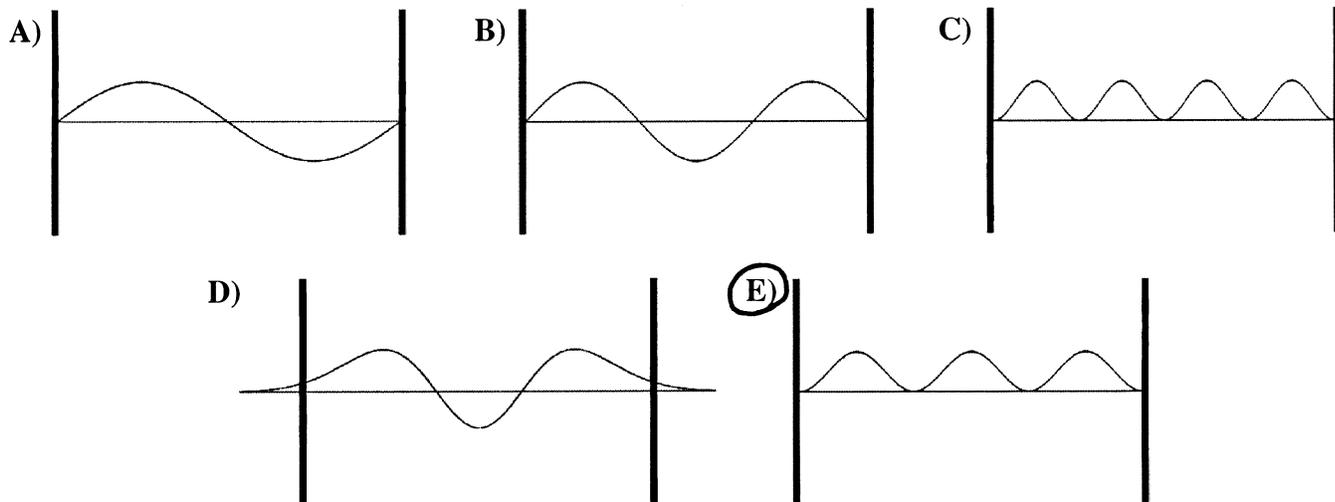
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   (A) Na, C, O, F   **B)** Na, C, F, O   **C)** F, O, C, Na

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3) Which of the following types of radiation has the highest energy?

   A) infrared   **(B)** X-ray   **C)** visible

   D) microwaves   **E)** radio waves   **F)** ultraviolet

4) In the photoelectric effect, increasing the intensity of the light will:

   A) cause the electrons to be emitted with higher kinetic energy if the frequency is sufficiently high.
   (B) cause more electrons to be emitted from the metal if the frequency is sufficiently high.
   C) ensure that electrons will be emitted from all metals.
   D) have no effect on the experiment.
   E) both **a** and **b**

5) Which plot corresponds to Ψ of 1-D particle in a box for $n = 3$?

B
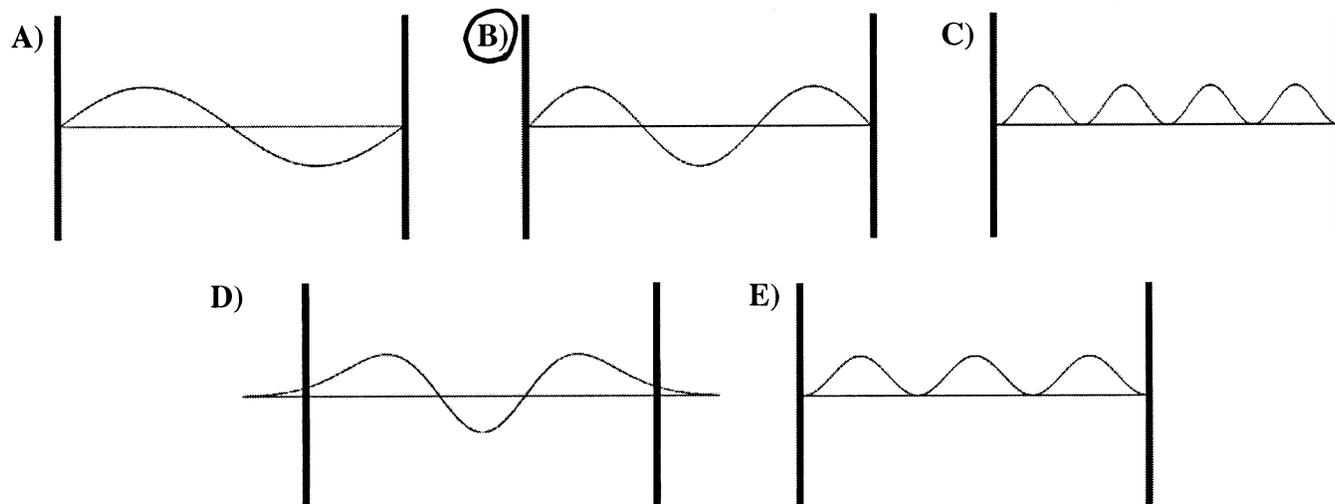
6) According to the Bohr model of the atom, which state is the *most weakly bound* (highest in energy)?

    A) $n = 2$ electron in He^+

    B) $n = 3$ electron in H

    C) $n = 1$ electron in He^+

    D) $n = 3$ electron in Li^{2+}

    E) $n = 2$ electron in H

7) A full quantum calculation of electronic structure indicates that the dipole moment of PH_3 is zero. Which statement(s) best explains this result?

    A) PH_3 violates the octet rule and does not exist.

    B) The electronegativities of P and H are very close in value; therefore, no bond dipoles exist.

    C) PH_3 is a trigonal planar structure and the bond dipoles cancel.

    D) **B** and **C** only

    E) **A, B,** and **C**

8) The uncertainty in the velocity of an electron is 1×10^5 m s^{-1}. What is the minimum uncertainty in its position?

    A) 5.79×10^{-10} m

    B) 2.31×10^{-10} m

    C) 5.79×10^{-5} m

    D) 2.31×10^{-9} m

    E) 1.08×10^{-10} m

B

Short Answer Question #1 [35 points total]

a) Anthracite coal can be represented by $C_{92}H_4O_3S$. Balance the following reaction. [10 points]

2 pts. per coeff.

___1___ $C_{92}H_4O_3S$ + __92.5__ O_2 $\longrightarrow$ __92__ CO_2 + __2__ H_2O + __1__ SO_2

or) 2   185   184   4   2
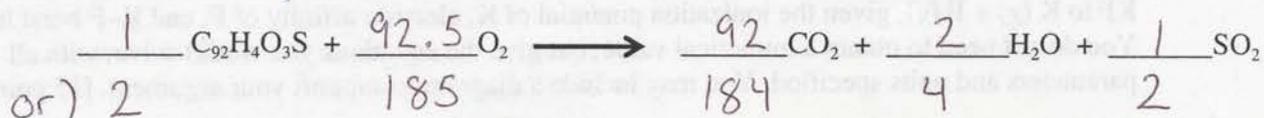
b) What mass of carbon dioxide is produced by the combustion of 1.00 kg of coal? [10 points]

$$1.00 \times 10^3 g \left(\frac{mol}{1189.02 g} \right) \left(\frac{92\, mol\, CO_2}{1\, mol\, coal} \right) \left(\frac{44.01 g}{mol} \right) = 3.41\ kg\ CO_2$$

Correct MM   Correct MM   Answer
4 pts   2 pts   4 pts.

c) Draw the Lewis dot structure for SO_2 (include all resonance structures). Indicate the bond order of each bond and the molecular shape of SO_2. [15 points]

$$\left[\ddot{\mathrm{O}} - \ddot{\mathrm{S}} = \ddot{\mathrm{O}} \quad \updownarrow \quad \ddot{\mathrm{O}} = \ddot{\mathrm{S}} - \ddot{\mathrm{O}} \colon \quad \updownarrow \quad \ddot{\mathrm{O}} = \ddot{\mathrm{S}} = \ddot{\mathrm{O}} \right]$$
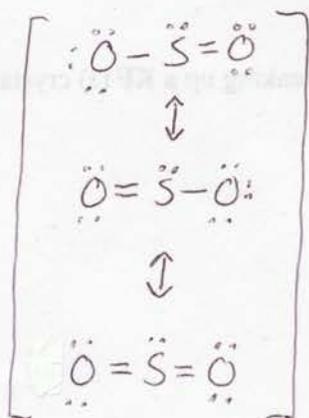
Bond order: $\frac{(2+2+1)}{3} = 1.6$ for both bonds

Steric number: 3 – trigonal planar (distorted)

or

bent – 117

(S with two O below)

3pts. each structure (9 total)
3pts. correct bond order for structure
3pts. correct geometry name for structure

A

Short Answer Question #2 [25 points total]

a) Explain how you would calculate the bond energy of diatomic KF, i.e., the energy required to convert KF to K (g) + F (g), given the ionization potential of K, electron affinity of F, and K–F bond length. You do not need to obtain a numerical value, but give the equations you would solve, with all parameters and units specified. You may include a diagram to support your argument. [15 points]

$$E_{ions} = IP_K - EA_F \quad \text{5pts}$$

$$E_{atoms} = 0$$

$$E_{coul} = -\frac{q_1 q_2}{4\pi\varepsilon_0 r} = -\frac{(+e)(-e)}{4\pi\varepsilon_0 r_{KF}} = \frac{e^2}{4\pi\varepsilon_0 r_{KF}} \quad \text{5pts.}$$

$$E_{Bond} = E_{coul} - E_{ions} = \frac{e^2}{4\pi\varepsilon_0 r_{KF}} - IP_K + EA_F \quad \text{5pts.}$$
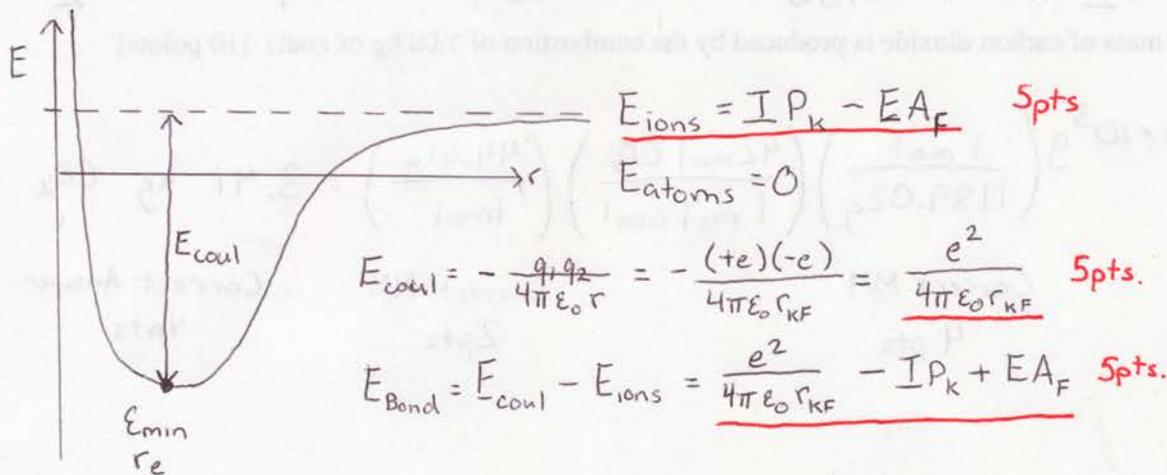
b) Which requires more energy – breaking a CaO (s) crystal into *ions* or breaking up a KF (s) crystal into *ions*? Rationalize your answer. [10 points]

CaO requires more energy because the interaction between a 2+ and 2− ions are stronger than the interaction between 1+ and 1− ions.

$$E_{coul} = -\frac{(+2e)(-2e)}{4\pi\varepsilon_0 r} \approx 4\times \text{ more.}$$

5pts for answer
5pts for justification

Midterm 1 Results

Midterm 1 Stats	
Mean	76.8
St. Dev.	11.7
Max	97
N	170
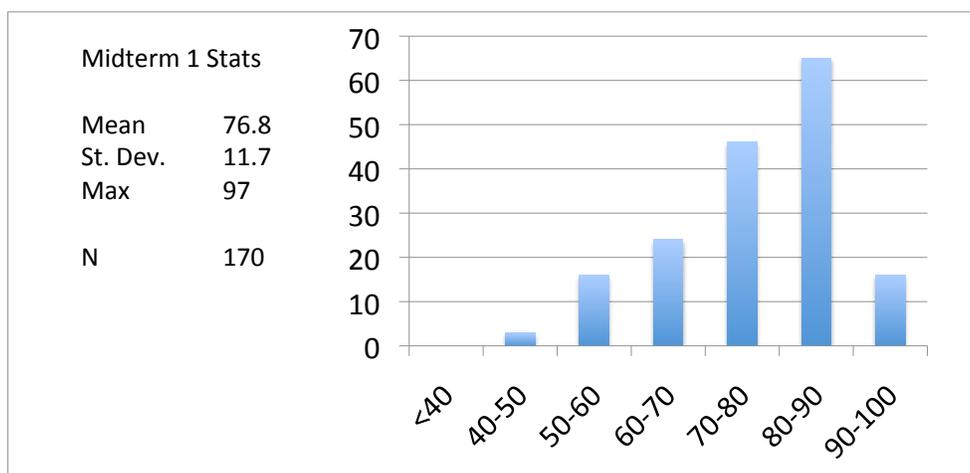
Exams will be returned in lab section this week.

If you think a question was graded incorrectly, **submit regrade request to GSI by 10/1**.
  Include an explanation of what was graded incorrectly and why.
  Entire exam will be rescored.
  Random exams (~10%) have been photocopied to deter academic dishonesty.