1. Which of the following diatomic species, according to the molecular orbital diagram below, is paramagnetic with the lowest bond order?
   a) $\text{N}_2^+$
   b) $\text{CN}^-$
   c) $\text{O}_2$
   d) $\text{F}_2$
   e) $\text{F}_2^-$

Questions 2 and 3 refer to the following 3 representations of molecular orbitals of a diatomic molecule. Atomic nuclei are represented by $\bullet$.

2. Which of the molecular orbitals above are bonding orbitals?
   a) I only
   b) II only
   c) III only
   d) II and III
   e) all of them

3. Which of the above are $\pi$ or $\pi^*$ molecular orbitals?
   a) I
   b) II
   c) III
   d) II and III
   e) all of them

4. Which of $\text{H}_2\text{O}$, $\text{CH}_3\text{Cl}$, $\text{H}_2\text{S}$ and $\text{O}_2$ would you expect to form strong hydrogen bonds?
   a) $\text{H}_2\text{O}$ only
   b) $\text{H}_2\text{O}$ and $\text{H}_2\text{S}$ only
   c) $\text{H}_2\text{O}$ and $\text{O}_2$ only
   d) $\text{H}_2\text{O}$, $\text{CH}_3\text{Cl}$ and $\text{H}_2\text{S}$ only
   e) all of them
5. One resonance structure of the carbonate ion is shown below. What is the bond order of the carbon–oxygen bonds in \( \text{CO}_3^{2-} \)?

- a) 1.0
- b) 1.33
- c) 1.5
- d) 1.66
- e) 2.0

6. What is the molecular geometry of the \( \text{NO}_3^- \) ion?
- a) trigonal planar
- b) tetrahedral
- c) trigonal pyramidal
- d) T-shaped
- e) square planar

7. What is the molecular geometry of the \( \text{ClO}_4^- \) ion?
- a) trigonal planar
- b) tetrahedral
- c) trigonal bipyramidal
- d) octahedral
- e) T-shaped

8. In which of the following are the atoms arranged in order of DECREASING first ionisation energy?
- a) Br, As, Se, Ge
- b) Li, Na, K, Rb
- c) P, S, Si, Al
- d) Kr, Ar, Ne, He
- e) Be, B, C, N

9. What is the concentration of lead in a water sample with an absorbance of \( A = 0.0068 \) if a reference sample containing 0.0100 ppm lead has an absorbance of 0.0165?
- (a) 0.0041 ppm
- (b) 4.1 ppm
- (c) 0.24 ppm
- (d) 0.011 ppm
- (e) 0.0038 ppm

10. The addition of solutes can result in boiling point elevation. Which one of the following sets of 0.1 M solutions is arranged in order of increasing boiling point?
- a) glucose < NaCl < NH_3 < Na_2SO_4
- b) glucose < HBr < Na_3PO_4 < Na_2SO_4
- c) Na_2SO_4 < Na_3PO_4 < HBr < glucose
- d) glucose < HBr < Na_2SO_4 < Na_3PO_4
- e) HBr < Na_2SO_4 < Na_3PO_4 < glucose

Correct answers: 1E, 2D, 3B, 4A, 5B, 6A, 7B, 8B, 9A, 10D
1. Which of the following diatomic species, according to the molecular orbital diagram below, is diamagnetic with the highest bond order?

   a) N$_2^+$
   b) CN$^-$
   c) O$_2$
   d) F$_2$
   e) F$_2^-$

2. Which of the molecular orbitals above are antibonding orbitals?

   a) I
   b) II
   c) I and II
   d) II and III
   e) none of them

3. Which of the above are π or π* molecular orbitals?

   a) I
   b) II
   c) III
   d) I and II
   e) none of them

4. Which of H$_2$O$_2$, CH$_3$OH, HF and H$_2$ would you expect to form strong hydrogen bonds?

   a) H$_2$ only
   b) H$_2$O$_2$ and HF only
   c) H$_2$O$_2$ and CH$_3$OH only
   d) H$_2$O$_2$, CH$_3$OH and HF only
   e) all of them
5. One resonance structure of ozone is shown below. What is the bond order of the oxygen–oxygen bonds in O₃?
   a) 1.0
   b) 1.33
   c) 1.5
   d) 1.66
   e) 2.0

6. What is the molecular geometry of the BeF₂ molecule?
   a) trigonal planar
   b) tetrahedral
   c) trigonal pyramidal
   d) T-shaped
   e) linear

7. What is the molecular geometry of the SF₆ molecule?
   a) trigonal planar
   b) tetrahedral
   c) trigonal bipyramidal
   d) octahedral
   e) T-shaped

8. In which of the following are the atoms arranged in order of DECREASING atomic radius?
   a) Li, Na, K, Rb, Cs
   b) P, Si, Al, Mg, Na
   c) Ca, K, Cl, S, P
   d) As, Se, Br, Kr, K
   e) Na, Mg, B, C, N

9. What is the concentration of copper in a water sample with an absorbance of A=0.035 if a reference sample containing 0.100 ppm copper has an absorbance of 0.083?
   (a) 0.024 ppm  (b) 0.24 ppm  (c) 0.042 ppm  (d) 0.029 ppm  (e) 0.035 ppm

10. The addition of solutes can result in boiling point elevation. Which one of the following sets of 0.1 M solutions is arranged in order of increasing boiling point?
    a) sucrose < NaCl < CH₃COOH < Na₂SO₄
    b) sucrose < HCl < Na₃PO₄ < K₂SO₄
    c) sucrose < CH₃COOH < MgCl₂ < K₃PO₄
    d) HBr < Na₂SO₄ < Na₃PO₄ < sucrose
    e) Na₂SO₄ < K₃PO₄ < HBr < sucrose

Correct answers:  1B, 2A, 3A, 4D, 5C, 6E, 7D, 8E, 9C, 10C