1. The boiling point of HF is greater than that of NH\(_3\) because:
   a) the HF bond has a higher dipole moment than the NH bond.
   b) the NH bond has a higher dipole moment than the HF bond.
   c) fluorine is a smaller and more electronegative atom than nitrogen, so the hydrogen bonds in HF are stronger than those in NH\(_3\).
   d) there is a greater density of hydrogen bonds in liquid HF.
   e) the dispersion forces between HF molecules are larger than those between NH\(_3\) molecules.

2. Which one of the following statements is incorrect?
   a) An atomic orbital with \(n = 2, l = 2, m = -1\) is an allowed solution of the electron wave equation for the hydrogen atom.
   b) An electron can exhibit diffraction similar to other wave-like phenomena.
   c) \(p\) orbitals are typically higher in energy than \(s\) orbitals with the same principal quantum number because the \(p\) electron is shielded from the nucleus by the \(s\) electrons.
   d) The quantised nature of the electron energies accounts for the observed line spectra of hydrogen.
   e) Placing 11 electrons into the five \(3d\) orbitals violates Pauli's Exclusion Principle.

3. Assuming that all of the ionic crystals have the same crystal structure, predict which of these will have the smallest (least negative) lattice energy.
   a) MgCl\(_2\)  b) CaCl\(_2\)  c) SrCl\(_2\)  d) BaCl\(_2\)  e) RaCl\(_2\)

4. Which one of the following statements is correct?
   a) Nearest-neighbour interactions in ionic crystals are repulsive.
   b) Cation radii are smaller than those of their parent atom.
   c) Metals are stabilised by a network of covalent bonds.
   d) Electrostatic interactions are directional.
   e) Cation radii are larger than those of their parent atom.
5. What is the specific activity (in Bq g^{-1}) of the nuclide $^{90}_{35}$Br, whose half-life is 1.6 seconds?
   a) $2.9 \times 10^{21}$  
   b) $2.3 \times 10^{25}$  
   c) $9.8 \times 10^{21}$  
   d) $2.8 \times 10^{25}$  
   e) $7.1 \times 10^{21}$

6. The thermal decomposition of potassium chlorate is a convenient preparation for small amounts of oxygen gas in the laboratory. The reaction is:
   $$2\text{KClO}_3(s) \rightarrow 2\text{KCl}(s) + 3\text{O}_2(g)$$
   What mass of potassium chlorate would produce a theoretical yield of 10.00 g of oxygen?
   a) 25.5 g  
   b) 30.4 g  
   c) 38.3 g  
   d) 51.1 g  
   e) 57.5 g

Questions 7 and 8 refer to the following experiment. 0.060 M aluminium nitrate solution (100 mL) is added to 0.080 M potassium phosphate solution (50 mL).

7. What amount (in mol) of aluminium phosphate precipitates?
   a) 0.0060  
   b) 0.0060  
   c) 0.0040  
   d) 0.0020  
   e) 0.040

8. What is the final concentration of Al^{3+}(aq) ions remaining in solution after the reaction?
   a) 0.020 M  
   b) 0.013 M  
   c) 0.040 M  
   d) 0.060 M  
   e) 0.010 M

9. What is the molecular geometry of the NO$_3^-$ ion?
   a) trigonal planar  
   b) tetrahedral  
   c) trigonal pyramidal  
   d) T-shaped  
   e) square planar

10. What is the molecular geometry of the XeO$_4$ molecule?
    a) trigonal planar  
    b) tetrahedral  
    c) trigonal bipyramidal  
    d) octahedral  
    e) T-shaped

Correct answers: 1C, 2A, 3E, 4B, 5A, 6A, 7C, 8B, 9A, 10B
1. The boiling point of CO$_2$ is less than that of SiO$_2$ because:
   a) the SiO bond has a higher dipole moment than the CO bond.
   b) the CO bond has a higher dipole moment than the Si bond.
   c) the hydrogen bonds in CO$_2$ are weaker than those in SiO$_2$.
   d) the dispersion forces between SiO$_2$ molecules are larger than those between CO$_2$ molecules.
   e) CO$_2$ is a molecular covalent compound whilst SiO$_2$ is a network covalent compound.

2. Which one of the following statements is incorrect?
   a) An atomic orbital with $n = 3$, $l = 2$, $m = -2$ is an allowed solution of the electron wave equation for the hydrogen atom.
   b) Emission spectra can only be collected from excited atoms or molecules.
   c) An electron's kinetic energy typically increases with the number of nodes in its wavefunction.
   d) Excitation of a Ca atom can result in both 4$s$ electrons having parallel spins.
   e) The angular momentum quantum number specifies the orbital shape.

3. Assuming that all of the ionic crystals have the same crystal structure, predict which of these will have the largest (most negative) lattice energy.
   a) LiCl    b) NaCl   c) KCl    d) RbCl    e) RbBr

4. Which one of the following statements is incorrect? Nearest-neighbour interactions in ionic crystals are repulsive.
   a) Nearest-neighbour interactions in ionic crystals are repulsive.
   b) Cation radii are smaller than those of their parent atom.
   c) Ionic crystals are stabilised by potential energy.
   d) Electrostatic interactions are non-directional.
   e) Smaller ionic radius increases the stability of a crystal.
5. What is the specific activity (in Bq g\(^{-1}\)) of the nuclide \(^{73}\text{Ga}\), whose half-life is 4.8 hours?
   a) \(2.4 \times 10^{16}\)  b) \(2.5 \times 10^{16}\)  c) \(3.3 \times 10^{17}\)  d) \(5.9 \times 10^{16}\)  e) \(8.7 \times 10^{16}\)

6. Hydrogen bromide reacts with manganese dioxide according to the following equation.
   \[
   \text{MnO}_2(s) + 4\text{HBr}(g) \rightarrow \text{MnBr}_2(s) + 2\text{H}_2\text{O}(g) + \text{Br}_2(g)
   \]
   What mass of bromine can be produced from 6.50 g of hydrogen bromide?
   a) 12.8 g  b) 6.42 g  c) 3.21 g  d) 1.60 g  e) 0.802 g

Questions 7 and 8 refer to the following experiment. 0.040 M chromium(III) chloride solution (100 mL) is added to 0.030 M sodium sulfide solution (50 mL).

7. What amount (in mol) of chromium(III) sulfide precipitates?
   a) 0.0005  b) 0.0015  c) 0.0020  d) 0.0030  e) 0.0045

8. What is the final concentration of \(\text{Cr}^{3+}(aq)\) ions remaining in solution after the reaction?
   a) 0.010 M  b) 0.015 M  c) 0.020 M  d) 0.030 M  e) 0.045 M

9. What is the molecular geometry of the BeF\(_2\) molecule?
   a) trigonal planar  
   b) tetrahedral  
   c) trigonal pyramidal  
   d) T-shaped  
   e) linear

10. What is the molecular geometry of the SF\(_6\) molecule?
    a) trigonal planar  
    b) tetrahedral  
    c) trigonal bipyramidal  
    d) octahedral  
    e) T-shaped

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