1. (a) Calculate the maximum wavelength of light needed to eject electrons from the surface of cesium, if light of wavelength 400 nm strikes the surface of the metal giving photoelectrons whose maximum kinetic energy is 1.54×10^{-19} J. (4 points)

(b) During an experiment, the maximum kinetic energy of ejected photoelectrons from the surface of cesium was found to be 11.4 eV. Determine the de Broglie wavelength of an electron with this energy. (4 points)
[Planck's constant $h = 6.63 \times 10^{-34}$ J s; velocity of $c = 3.00 \times 10^{8}$ m/s; electron mass me = 9.11×10^{-31} kg; 1eV = 1.60×10^{-19} J]

2. (a) The energy of a particle, such as an electron, confined to a one-dimensional box of length L, such that its potential energy is 0 for x = 0-L and ∞ for all other values of x, is given by

1,25.10⁻⁹nm

$$E_n = \frac{h^2}{8m_e}\frac{n^2}{L^2}$$

Calculate the energy difference in kJ/mol between the ground state and first excited state for an electron,

(i) in a 1.0 Å box, and

(ii) in a 1.0 m box (total 6 points for (i) and (ii)).

(iii) Comment on the result. (2 points)
[Electron mass me = 9.110×10^{-31} kg; Planck's constant $h = 6.626 \times 10^{-34}$ Js; Avogradro's number is 6.022×10^{23} /mol; 1 Å = 10^{-10} m]

(b) Write an equation for the energy of an electron confined to a 3-dimensional cubic box of length L, under the conditions described above. (2 points)

(c) Write an equation for the ground state energy level. (2 points)

(d) Write an equation for one of the first excited state energy levels. (2 points)

(e) State how many first excited energy levels exist and state whether or not they are degenerate (of equal energy). (2 points)

3. Give the value of quantum numbers (n, l, and m) and the number of radial nodes and angular nodes for each of the following hydrogen atomic orbitals in the table. (5 x 2 points)

Orbital	n	l	m	No. of radial nodes	No. of angular nodes
2s					
$2p_y$					
4s					
$5p_x$					
$4d_{z2}$					

4. The cesium atom has one of the lowest ionization energies of all neutral atoms in the periodic table (375.5 kJ/mol). Calculate the longest wavelength of light that could ionize

a cesium atom (in the gas phase) and state the region of the electromagnetic spectrum to which this light belongs. (6 points)
[Planck's constant $h = 6.626 \times 10^{-34}$ Js; Avogradro's number is 6.022×10^{23} /mol; velocity of light $c = 2.998 \times 10^{8}$ m/s]

5. (a) Using the standard notation, write ground state electronic configurations for the following species and describe each one as diamagnetic or paramagnetic.

(i) Li^- (ii) S^- (iii) Br^+ (iv) Te^{2-} (v) Xe^+ (2.5 points)

(b) For each of the following pairs of atoms or ions, state which you expect to have the larger radius. No explanation is needed.

(i) Ge or As (ii) Sm and Sm^{3+} (iii) Rb^+ or Kr (iv) Sr^+ or Rb (v) I^- or Xe (2.5 points)

(c)

(i) Arrange the following in order of their first ionization energies: Li, Be, B.
No explanation is needed. (2 points)

(ii) Explain briefly which of the following atoms has the smallest radius: Si, S, Mg. (3 points)

6. (a) Write the equation that defines the lattice energy of calcium oxide. (2 points)

(b) Predict which of the following pairs of ions would have the greater coulombic attraction in a solid compound: (i) K^+, O^{2-} (ii) Ga^{3+}, O^{2-} (iii) Ca^{2+}, O^{2-} (2 points)

(c) Predict which of LiCl(s) or RbCl(s) would have the higher lattice energy, given that they have similar arrangements of ions in the crystal lattice. (2 points)

7. (a) Draw one Lewis structure for each of the following, showing all valence electron pairs and all nonzero formal charges.

(i) Ozone (O_3) (ii) Boron trifluoride (BF_3) (iii) Triiodide ion (I_3^-) (iv) Xenon octafluoride dianion (XeF_8^{2-}). (4 x 1.5 = 6 points)

(b) Explain why the observed structure of ozone has O-O bonds that are both identical and intermediate in length between O-O and O=O. (2 points)

(c) Explain why the B-F bonds in BF_3 are rather shorter than expected. (2 points)

8. Consider the molecule bromine trichloride ($BrCl_3$) and answer the following questions.

(a) Draw the three possible structures of $BrCl_3$, according to the VSEPR model. (6 points)

(b) Select the most stable structure. (2 points)

(c) State whether the geometry of the most stable structure is regular or distorted. (2 points)

(d) State whether the most stable structure has a dipole moment. (2 points)

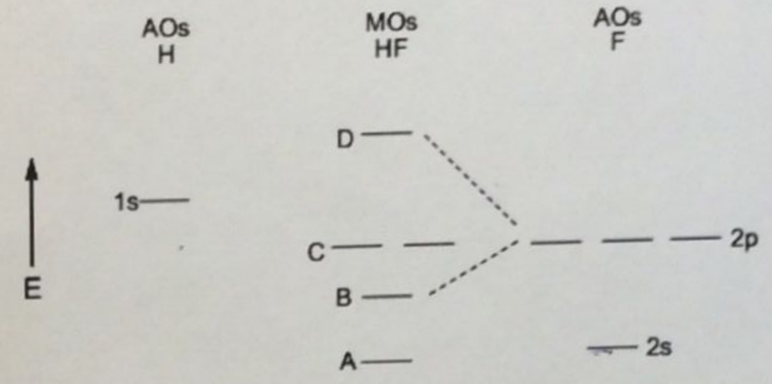
9. (a) Sketch a valence bond (VB) model of the *cis* stereoisomer of diazene (HNNH), showing the hybridization on the N atoms, the σ skeletal structure, lone pair electrons and π-bonding. (5 points)

(b) State whether *cis*-diazene has a molecular dipole moment. (1 point)

(c) Sketch a molecular orbital energy diagram (showing all relevant atomic and molecular orbitals) for the homonuclear diatomic molecule B_2. (5 points)

(d) Determine, from its electronic structure, whether B_2 is paramagnetic or diamagnetic. (1 point)

10. Consider the LCAOMO diagram for HF below and answer the following questions.



(a) Label the MOs of HF. (4 points)

(b) Write the electron configuration of HF and determine the highest (energy) occupied MO (HOMO) and the lowest (energy) unoccupied MO (LUMO). (3 points)

(c) Sketch the LUMO of HF. (3 points)