1. Distinguish between:
   a) atom  
   -smallest particle of an element  
   -pure substance, made of atoms  
   Both a) and b) cannot be broken down by ordinary means
   
   b) element
   -some elements, and compounds exist with particles called molecules  
   Both c) and d) can be chemically broken down
   
   c) molecule
   -particle consisting of a cluster of atoms
   
   d) compound
   -pure substance
   -2 or more elements

2. Give five examples of EACH elements and compounds found in the human body.  
   Ca, C, N, K, F, etc.  
   \( \text{O}_2, \text{CO}_2, \text{CO}, \text{H}_2\text{O}, \text{C}_6\text{H}_{12}\text{O}_6, \text{NH}_3, \text{etc}. \)

3. Draw a representative (chemistry appropriate) diagram of a BIOLOGICAL atom showing your placement of protons, neutrons, and electrons.
   
   - Eg. Carbon:
   
   ![Carbon diagram](image)

4. Show your elemental atom in standard atomic notation. Use labels to show what each item represents (reference: p. 8, Fig. 1)
   \( ^{12}_6\text{C} \)
   
   Top number – Atomic mass – sum of \( p^+ \) and \( n^0 \)
   
   Bottom number – Atomic number - # of \( p^+ \)
   
   Letter – Element symbol

5. a) Carbon-14 is considered to be an isotope of carbon. What does this mean?  
   Draw a Bohr diagrams to represent it.
   
   ![Bohr diagram](image)
   
   b) How is carbon-14 different than some other isotopes? What happens to it over time?
   - radioactive – eg. of a radioisotope
   - will emit radiation over time (nucleus unstable)

   c) Define half-life.
   - time it takes for one half of a radioactive sample to decay
   - eg. C – takes 5730 years for 100 radioactive atoms to become 50 radioactive atoms and 50 non-radioactive atoms

   ![Half-life calculation](image)
d) What are three biological uses of isotopes?
   Radioactive tracers – follow chemicals through bodily reactions
      - trace path of chemicals through the body (C-14, H-3)
   Radiometric dating – to estimate how old a sample is (C-14 dating)
   Radiation Treatment – to kill certain tumours or to irradiate food to maintain shelf-life
   Diagnosis of Disease – (I-131 → thyroid gland)

6. Distinguish between an energy level and an orbital? What is an orbital’s maximum capacity?
   Energy level corresponds to the potential energy level away from the nucleus in which an electron resides
   Orbitals are located within certain energy levels and represent volumes of space where one is most likely to find an electron
   Max capacity = 2

7. What are valence electrons? Why are they particularly of interest to scientists?
   Outermost electrons in an energy level; determine the reactivity of an element; are involved in reactions

8. Show a biological element with a Lewis dot diagram.
   
   ●
   ● C ●
   ●

9. a) What is meant by an atom being neutral?
   - has an equal number of \( p^+ \) and \( e^- \)

   b) What is an ion? Describe its electron arrangement.
      - charged atom – an atom that has either lost or gained \( e^- \)
      - it will have a complete or empty outer electron shell (valence)

   c) Differentiate between a cation and anion.
      - cations are positive; anions are negative

   d) Give 5 examples of ions found in the human body.
      - Too many to write down – most of your examples for elements actually exist as ions (except C, H, N, O, P, S)

10. a) What is a chemical bond?
    - an attractive force that exists between two atoms

 b) Why is this an important term for biologists to understand?
    - represent stable groupings of atoms that can be used to create cellular structures
    - represent sites of stored energy that can be extracted to drive cellular processes

11. a) Differentiate between:
    i) ionic bond  ii) pure covalent bond  iii) polar covalent bond
    i) ionic – attraction of a positive ion to a negative ion that results from a transfer of electrons; \( \Delta E_n > 1.7 \)
ii) pure covalent – attraction between, atoms of the same type where electrons are shared between atoms (H₂) \( \Delta E_{n} = 0 \)

iii) polar covalent – attraction between atoms of a different type where electrons are unequally shared between atoms; creates a \( \delta^{+} \) and \( \delta^{-} \) end \( 0 < \Delta E_{n} < 1.7 \)

b) What types of atoms form these types of bonds?

- Ionic – metal/non-metal
- Pure covalent – 2 non-metals of the same type
- Polar covalent – 2 non-metals of different type

c) What does the term electronegativity refer to? What is the importance of such a measure?
- Refers to an element’s ability to attract electrons towards itself
- Gives an idea of how well electrons are shared between atoms (linked to strength of the force of attraction)

12. Draw Lewis dot/electron dot diagrams or structural diagrams for the compounds below. State the type of bonding that is taking place (pure covalent, polar covalent, ionic)

   a) \( \text{O}_2 \) – pure covalent bond
   b) \( \text{H}_2\text{O} \) – polar covalent bonds
   c) \( \text{NaCl} \) – ionic bond
   d) \( \text{CH}_4 \) – polar covalent bonds

13. What happens to orbitals of different atoms during bonding? Why is this significant with respect to the molecule?
- Hybridize – change in the orbitals participating in bonding such that valence electrons change orientation
- Helps determine molecular shape and overall polarity of molecule

14. What does it mean if a molecule is polar?
- There is an unequal distribution of charge over one end of a molecule versus the other

15. How can a molecule have polar covalent bonds but be classified as non-polar?
- If all the individual pulls along the bonds cancel out the molecule will have a symmetrical distribution of charge around it

16. Why would polarity be an important idea for biologists to understand?
- Influences what will dissolve in water (eg. blood) versus that of fat
- Gives water some unique properties that allow life to exist
- Affects the reactivity of molecules within our cells

17. Differentiate between an intermolecular and intramolecular force. Give an example of each.
- Intermolecular is between molecules (eg. van der Walls interaction – London forces, dipole-dipole attraction, H bonds)
- Intramolecular is within a molecule (eg. ionic or covalent bond)

18. Give three examples of biological reactions?
- Neutralization (Acid-Base)
- Oxidation-Reduction
- Condensation / Hydrolysis

19. a) Differentiate between an acid and base.
   Acid – substance that produces hydrogen ions in water
   Base – substance that results in hydroxide ions being produced in water

b) What does pH mean?
   - Power of hydrogen – measure the concentration of hydrogen ions in solution

c) Draw and label the pH scale demonstrating where the acids would be found, and where the bases would be found.

   0               7               14
   Acids       Neutral       Bases

d) What is the approximate pH of your stomach? blood? small intestine?
   Stomach pH=2     Blood pH=7.4     S.Intestine pH=8

e) What is a hydronium ion? Why is it technically incorrect to call a hydronium ion a hydrogen ion?
   - hydronium ion is a water molecule with an additional proton (H⁺) attached to one of
     water’s lone pairs of electrons (this makes it positive)
   - the proton does not exist on its own but instead is attached to a water molecule

f) What is it called when an acid is added to a base in equal proportions? Provide a sample equation. Identify the products.
   Neutralization:       Acid + Base \rightarrow Salt + Water
   \text{HCl}_{(aq)} + \text{NaOH}_{(aq)} \rightarrow \text{NaCl}_{(aq)} + \text{H}_2\text{O}(l)

g) What is the difference between a strong acid and a weak acid?
   Strong acids completely dissociate in water producing a high concentration of
   hydronium ions
   Weak acids partially dissociate in water producing a lesser concentration of hydronium ions