

1 Cognitive reasoning for the chemical sciences 4.4

1. *State whether the following pairs of statements are synonymous, ie., does knowing the facts in one set allow you to deduce the information in the other set and vice-a-versa. Please explain your answer.*
 - (a) **An ideal gas**
 - i. p , V , and T
 - ii. n , V , and T
 - (b) **An electron in an atom**
 - i. The electron's Z_{eff} and E_{tot}
 - ii. The electron's E_K and its n , the principal quantum number
 - (c) **The photoelectric effect**
 - i. A photon of known frequency strikes a hydrogen atom in its first excited state, ejecting the electron.
 - ii. A photon of strikes a hydrogen atom in its first excited state, ejecting an electron whose velocity is measured.
 - (d) **An ideal gas**
 - i. p , V , and T
 - ii. n
 - (e) **An electron in an atom**
 - i. The electron's Z_{eff} and E_{tot}
 - ii. The electron's E_K and its l , the total angular momentum quantum number
 - (f) **An electron in a box**
 - i. n and L
 - ii. n and λ
 - (g) **An atom and light**
 - i. The frequency of the photon accepted in going from the $n = 1$ state to the $n = 2$ state exactly equals the frequency of the photon emitted in going from the $n = 2$ state and the $n = 1$ state.
 - ii. The atom is in its ground state
 - (h) **An atom**
 - i. The outermost electron's Z_{eff} for both the ground state and the first excited state are identical.
 - ii. The atom is a noble gas.
 - (i) **An ideal gas**
 - i. pV
 - ii. nT

(j) **An atom or a molecule**

- i. The frequency of the photon accepted in going from the ground state to the first excited state exactly equals the frequency of the photon emitted in going from the first excited state to the ground state.
- ii. The system is not a molecule.

(k) **An atom**

- i. The atom is in its ground state; no subshell is partially filled; and the highest energy filled shell is an $l = 1$ shell.
- ii. A noble gas atom in its ground state.

(l) **An ideal gas**

- i. T/p
- ii. n/V

(m) **A neutral main-group atom**

- i. The outermost electron's Z_{eff} for both the ground state and the first excited state (in which a change in its n value has taken place) are close in value.
- ii. The atom is an alkali metal.

(n) **An atom**

- i. For this +2 charged atomic ion the energy of the $4s$ and $4f$ electron are exactly the same.
- ii. Li^{2+}

2. **Most and least probable locations for electrons in atomic orbitals**

- (a) Describe the location of points where an electron in a $2p_z$ orbital is most probably located.
- (b) Describe the location of points where an electron in a $4d_{x^2-y^2}$ orbital is least probably located.
- (c) Describe location of points where an electron in a $3d_{xy}$ orbital is most probably located.

3. **A particle in a box**

- (a) A box becomes 28 % shorter. What is the change in energy of the $n = 3$ state?
- (b) A box becomes 28 % shorter. What is the change in energy of the $n = 17$ state?
- (c) A box becomes 28 % shorter. What is the change in the number of nodes of the $n = 17$ state?
- (d) A box becomes 28 % shorter. What is the change in the number of places in the interior of the box where the electron is most probably located for the $n = 17$ state?