

## 1 Cognitive reasoning in the chemical sciences 5.3

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) **Photoelectric spectroscopy**
    - i. A molecule shows three peaks in its photoelectron spectrum.
    - ii. There are three filled molecular orbitals in its MO diagram.
  - (b) **Atomic configurations**
    - i. The energy of the atom/ion's  $2s$  orbital and the  $2p$  orbitals are to several significant figures exactly the same.
    - ii. The atom/ion has only one electron.
  - (c) **Photoelectric spectroscopy**
    - i. A molecule shows three peaks in its PES.
    - ii. All filled molecular orbitals are located at one of three different energies.
  - (d) **Electron configurations**
    - i. An atom/ion has in its ground state the electron configuration  $(1s)^2(2s)^2(2p)^1$
    - ii. The atom/ion is boron.
  - (e) **Main group diatomic molecule**
    - i. A main group diatomic molecule has exactly ten valence electrons. The molecule is paramagnetic.
    - ii. A main group diatomic molecule has exactly ten valence electrons. The  $\pi_x$  and  $\pi_y$  orbitals are lower in energy than the third lowest energy  $\sigma$  orbital.
  - (f) **Hybridization**
    - i. A pair of  $s$  and a  $p$  orbitals on the same atom are mixed equally.
    - ii. A pair of  $sp$  hybrid orbitals are generated.
  - (g) **Effusion**
    - i.  $T$  is constant. There are two gases,  $A$  and  $B$ , contained inside a flask where effusion can take place. The two gases are present in the flask in the same concentration.  $A$  effuses 30% faster than  $B$ .
    - ii.  $T$  is constant. There are two gases,  $A$  and  $B$ , contained inside a flask where effusion can take place. The two gases are present in the flask in the same concentration. The mass of  $A$  is  $\sqrt{1.3}$  slower than  $B$ .
  - (h) **An electron in a box**
    - i.  $n$  is doubled.
    - ii. The number of places inside the box where the electron can be at its least probable position doubles.