Revised August 2007

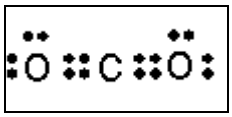
AP WORKED ANSWERS

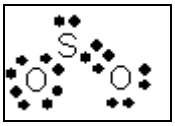
1995, 7

Points 1, 3, 2, 2

(a) Oxygen is paramagnetic (has unpaired electrons), nitrogen is diamagnetic (no unpaired electrons). (In order to understand this answer, Molecular Orbital theory is required. MO theory is seldom (if ever) discussed on AP courses and is **NOT** necessary in order to score the AP points on this question. – See page 2).

(b)





The CO_2 molecule is linear, so the individual bond dipoles cancel out. The SO_2 molecule is bent, causing the individual dipoles not to cancel out, resulting in a net dipole on the molecule.

(c) Co^{2+} has a partially filled d sub-shell, whereas the d sub-shell in Zn^{2+} is filled. As a result, an electron can be excited between d orbitals in Co^{2+}, causing visible light absorption; this cannot happen in Zn^{2+}.

(d) Si has all of its valence electrons localized in covalent bonds (in a giant network); hence it is a poor conductor.

Introduction of As atoms with their "extra" electrons into the Si lattice allows for an increase in conductivity.

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In a molecule, outer-shell atomic orbitals are combined to form molecular orbitals. Each set of molecular orbitals is split into a bonding and an anti-bonding set, one at a lower energy than the other. These molecular orbitals are filled, lowest energy first (as expected) and with the application of Hund's rule. This leads to the orbital filling patterns shown below.

ATOMIC ORBITALS of O atom $[He]\ 2s^2\ 2p^4$	MOLECULAR ORBITALS of O_2 Molecule	ATOMIC ORBITALS of O atom $[He]\ 2s^2\ 2p^4$	ATOMIC ORBITALS of N atom $[He]\ 2s^2\ 2p^3$	MOLECULAR ORBITALS of N_2 Molecule	ATOMIC ORBITALS of N atom $[He]\ 2s^2\ 2p^3$
	Đ Đ - Anti-Bonding			- - - Anti-Bonding	
2p ¬ Đ Đ		2p ¬ Đ Đ	2p Đ Đ Đ		2p Đ Đ Đ
	¬ ¬ ¬ Bonding			¬ ¬ ¬ Bonding	
	¬ Anti-Bonding			¬ Anti-Bonding	
2s ¬		2s ¬	2s ¬		2s ¬
	¬ Bonding			¬ Bonding	

As can be seen, in O_2, oxygen molecules, there are unpaired electrons, but in N_2, Nitrogen molecules, there are no unpaired electrons .