CHEMISTRY 1A (CHEM1101) June 2012

NB These answers have not been checked

2012-J-2

- 180 days

  The ${}^{131}_{53}\text{I}$ nucleus lies outside the zone of stability - its neutron to proton ratio is too high.

  ${}^{131}_{53}\text{I} \rightarrow {}^{131}_{54}\text{Xe} + {}^{0}_{-1}\beta$

- ${}^{131}\text{I}$ would do more damage. It has the shorter half-life so undergoes more disintegrations and produces more radiation in a given time period.

2012-J-3

- The square of the wavefunction provides a measure of electron density (*i.e.* the probability of finding an electron) at a given point around the nucleus of an atom.
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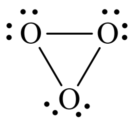
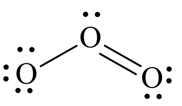
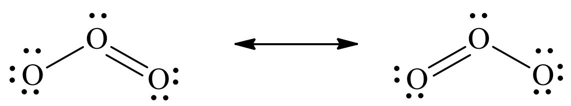




Ozone adopts the non-cyclic structure. The cyclic structure is very strained with bond angles of 60° instead of 109.5°, making it very unstable. In contrast, the second structure is stabilised by resonance.

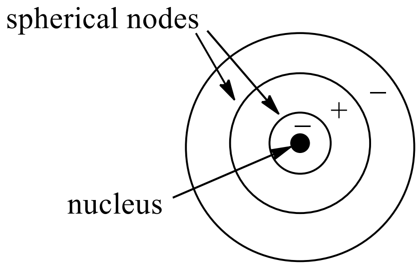


Ozone does not contain 1 double and 1 single bond. Both the O-O bonds are exactly the same length and true structure is a sort of average of the two Lewis structures shown. The energy of the true structure is lower than the theoretical energy for either of the given structures. This energy difference is known as resonance stabilisation energy.

2012-J-4

- 208 nm

  0, 1, 2, 3



2012-J-5

- A is a conductor. As there is no energy gap between them, electrons can easily be promoted from the filled to the unfilled electron energy levels. They are hence free to move if a voltage is applied.

  B is an insulator. There is a large energy gap between the filled and unfilled electron energy levels. As the electrons can't get to the unfilled levels (the conductance band), B is unable to conduct.

  No effect on A. There's no effect on the energy levels so electrons can still be promoted easily into the conductance band.

  B will become an n-type semi-conductor. The extra electrons are forced into the conductance band and are free to move when a voltage is applied. There aren't very many of these extra electrons, so the result is a material which can conduct some current, but not a lot.

2012-J-6

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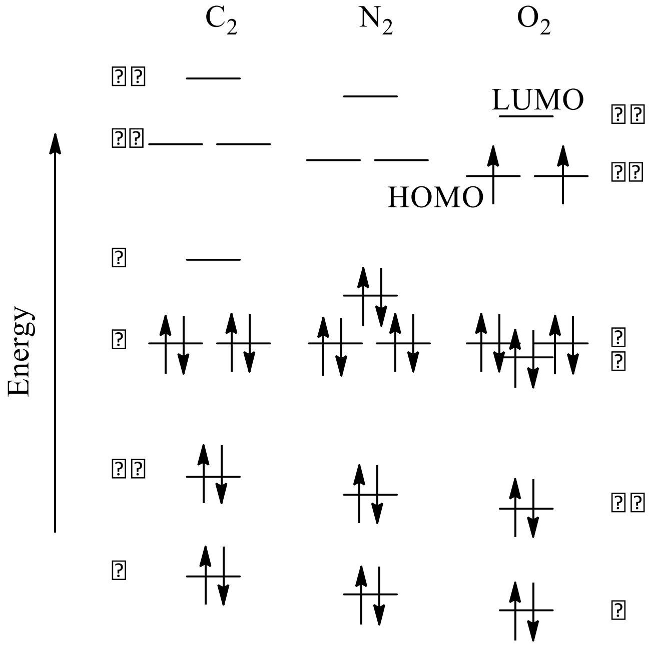
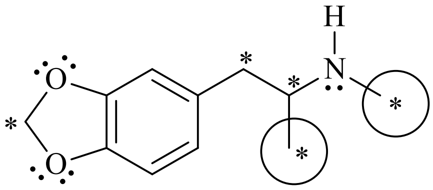


Bond order: 2 3 2

The atomic number of the elements increase moving across a period, reflecting an increase in the number of protons. This results in an increasing effective nuclear charge which pulls the electrons closer to the nucleus and lowers the energy of their orbitals.

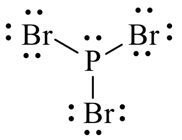
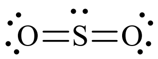
2012-J-7

- 

  amine

  6

-

	trigonal pryamidal
	bent (~120°)

2012-J-8

- Spontaneity requires a negative Gibbs free energy, *i.e.* $\Delta G = \Delta H - T\Delta S < 0$.
  The ΔH component is very large and positive because of the very strong Si-O bonds in SiO_2, a network covalent compound. Although ΔS is large and positive, it is not large enough to make the above expression negative, except at very high temperatures.

- 200 g (to 1 significant figure - calculator gives a value of 168)

2012-J-9

- 27.8 °C

- Nitrogen fixation is the conversion of relatively inert atmospheric nitrogen gas (N_2) into forms (*e.g.* NH_3, NO_3^-) that can be used by biological systems. Typically soil bacteria and leguminous plants convert N_2 into NH_4^+ ions.

2012-J-10

- 2.05 mol

2012-J-11

- –149.0 kJ mol^{-1}

  Complete combustion of ethane generates the maximum amount of CO_2 and H_2O and the maximum amount of heat. The pyrolysis reaction is essentially a partial oxidation and therefore generates less heat.

  The pyrolysis based reaction does not produce CO_2, a greenhouse gas.
  The product, ethylene (C_2H_4), is an important component in the polymer industry.

2012-J-12

- No reaction
  $C + SnO \rightarrow CO + Sn$
  $Zn + SnO \rightarrow ZnO + Sn$

  Any except $2C + O_2 \rightarrow 2CO$. All other reactions have a gaseous reactant and solid products. Gases have greater entropy than solids, so entropy is decreasing.

2012-J-13

- $Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$
  $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O$
  $4Cr(s) + 3O_2(g) + 12H^+(aq) \rightarrow 4Cr^{3+}(aq) + 6H_2O$

- In acidic conditions

  $$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O \qquad E° = +1.23 \text{ V}$$

  Applying Le Chatelier's principle to the reduction reaction, increasing $H^+(aq)$ will push the reaction to the right, thus increasing its reduction potential. O_2 thus becomes a stronger oxidant as the acidity increases.

2012-J-14

- $Fe^{3+}(aq)$
  3
  0.45 V
  6.8×10^{22}
  E_{cell} increases (from Le Chatelier's principle)
  0.49 V

2012-J-15

- For the tetrahydrides, the boiling points are determined by the size of the dispersion forces between molecules. The bigger the atoms, the more polarisable their electron clouds and the greater the dispersion forces. Hence boiling points are in order: $SnH_4 > GeH_4 > SiH_4 > CH_4$.

  Dispersion forces also operate in HF, HCl, HBr and HI, but here the dipole formed between the halogen atom and the hydrogen also needs to be considered. The Group 14 hydrides are all tetrahedral molecules with zero dipole moments. The non-H atom in each pair (*e.g.* HI, SnH_4) are from the same period, so have similar sizes and numbers of electrons and hence similar polarisabilities. The Group 17 hydrides consistently have higher b.p. than the corresponding Group 14 hydrides due to having dipole-dipole forces as well as similar dispersion forces.

  F is a very small and very electronegative atom. The H–F bond is therefore highly polarised and H-bonds form in this liquid. These are much stronger than dispersion forces or dipole-dipole forces and so HF has an anomalously high b.p. (There are no H-bonds in the other Group 17 halides as Cl, Br and I are not electronegative enough.) The dispersion forces in HCl, HBr and HI are more significant than the dipole-dipole forces as can be evidenced by the order of boiling points HI > HBr > HCl.