CHEM101/3, D1 **Final Practice Questions** 2010 11 27

HT

Answers

1. a. $KMnO_4$, b. Ag_2O, c. sodium hypochlorite

d. iron (III) sulfate, e. Lithium hydrogen phosphate

2. a. mass $H_2O \rightarrow$ mass H $\rightarrow$ % H $\rightarrow$ % B

$$9.01 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{2 \text{ mol H}}{1 \text{ mol } H_2O} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} = 1.008 \text{ g H}$$

$$\underline{\underline{\%H}} = \frac{1.008 \text{ g(H)}}{5.33 \text{ g(sample}} \times 100\% = \underline{\underline{18.9\%}} \qquad \underline{\underline{\%B}} = 100\% - 18.9\% = \underline{\underline{18.1\%}}$$

b. Assume 100 g borane.

	mass	moles	ratio	integer ratio
B	81.1 g	7.50	1.00	2
H	18.9 g	18.75	2.50	5

$\therefore$ empirical formula $\underline{\underline{(B_2H_5\ )}}$

c. empirical formula mass :

$(2 \times 10.81) + (5 \times 1.008) = 26.7$ g / mol.

The molar mass is about $2\times$ this value;

therefore the molecular formula is

$\underline{\underline{B_4H_{10}}}$

3a. Since there is excess $C(s)$ and the reactants/products of interest are gases we can do the reaction table using partial pressures.

$$C(s) + CO_{2(g)} \longrightarrow 2\ CO_{(g)}$$

I	4.00	0.00
C	$-x$	$+2x$
F	$4.00-x$	$2x$

$$P_t = P_{CO_2} + P_{CO} = 4.00 - x + 2x = 5.25$$

$$4.00 + x = 5.25$$

$$x = 5.25 - 4.00 = 1.25$$

$$\therefore P_{CO_2} = 4.00 - x = \underline{\underline{2.75\ \text{atm}}}$$

$$P_{CO} = 2x = \underline{\underline{2.50\ \text{atm}}}$$

It is assumed that Dalton's Law of Partial Pressure applies.

b. The presence of $N_2(g)$ has no influence on the rxn. The partial pressures remain the same.

$$\therefore P_{CO_2} = 2.75\ \text{atm},\ P_{CO} = 2.50\ \text{atm}\ P_{tot} = 2.75 + 2.50 + 1.00$$

$$= \underline{\underline{6.25\ \text{atm}}}$$

c. The size of the rxn container has no influence on the partial pressures. Therefore the answers are as under a.

4. a. "a" takes into account the extent of IMF's..

"b" takes into account the volume of the molecules themselves

b. crystalline: molecular particles are arranged in a <u>patterned structure</u> (Lattice)

amorphous: molecular particles are <u>randomly</u> arranged

c. Acc. to the Ideal Gas Law, molar mass and density are proportional.

$$pV = nRT$$

$$\vdots$$

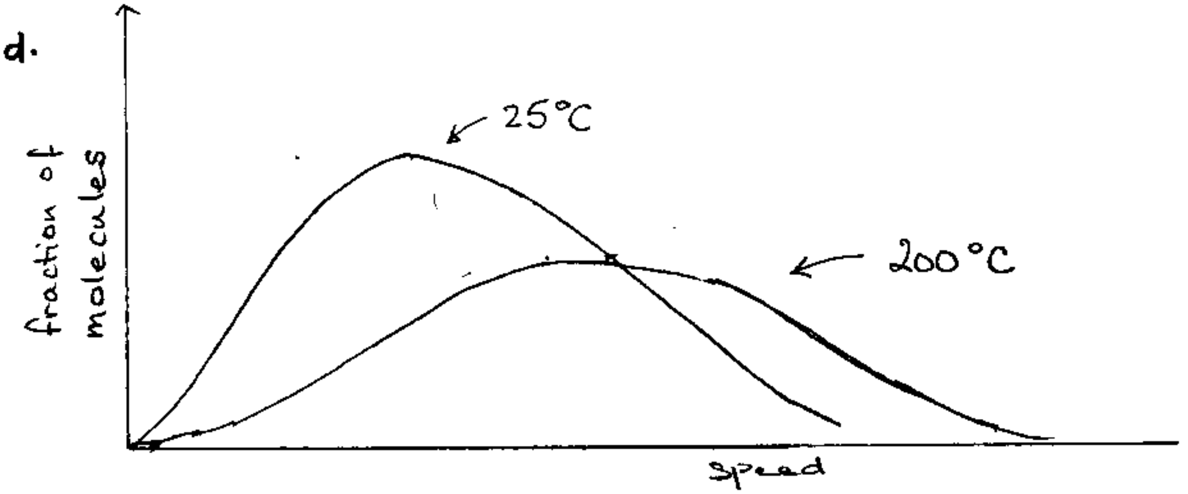
$$MM = D\frac{nRT}{P} \; ; \quad MM \propto D$$

$MM(N_2) = 28$ g/mol $MM(Ne) = 20$ g/mol

$\therefore$ <u>N_2 is more dense</u>

At very high temperatures, N_2 breaks down into N atoms; under these conditions one might argue that nitrogen (N) becomes less dense.

d.



5.a. Substances with stronger IMF's have higher b.p.

- O_2 is nonpolar, has only some weak LDF's
- CH_3CH_3 is also nonpolar, but LDF's are larger than in O_2 b/c it is a larger molecule that has more e^-'s and is more easily polarized
- CH_3OH forms H-bonds, strongest IMF's.

∴ O_2 lowest b.p.; CH_3OH highest b.p.

b. · C_8H_{18} (not C_8H_{16}) is largely nonpolar but has substantial LDF's.

- Substances with similar IMF's will dissolve best
- H_2O is polar; will not dissolve much
- CH_3OH has a small amount of LDF's, but also H-bonding.
- $CH_3(CH_2)_5OH$ has a longer nonpolar chain which matches the C_8H_{18} chain and only a minor amt of H bonding

∴ $CH_3(CH_2)_5OH$ is most soluble; H_2O least soluble.

5. c. For ionic substances, the m.p. depends largely on the strength of electrostatic forces. between the ions in the crystall Lattice.

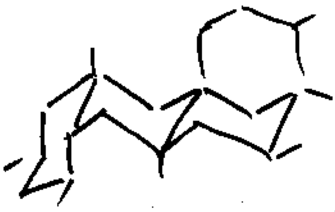
Electrostatic forces increase with the charge of the ions and decrease with the size of the ions.

- In $Ca^{2+}O^{2-}$, the charges are larger
- In CaO, Ca^{2+} is smaller than Na^{+} in NaF, while O^{2-} is Larger than F^{-}
- So let's ignore the size of the anions, the other factors indicate that the electrostatic forces in CaO are larger.

∴ CaO has a higher m.p.

6. a.

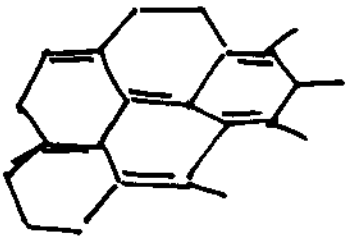
diamond



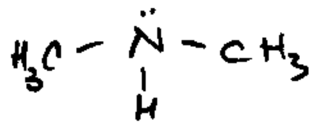
3-D network of covalent bonds

or similar

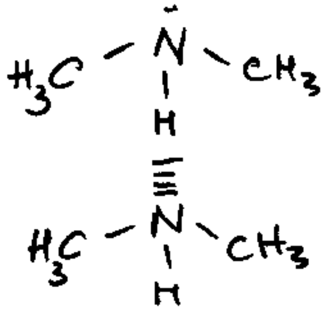
graphite

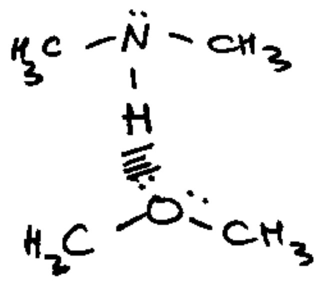


sheets of these on top of each other

6b.  , 

Only the H on the N in dimethylamine can be involved in H-bonding. It can "bond" to O of CH_3OCH_3 or N of $CH_3-NH-CH_3$.





7. a. Shortest $\lambda \rightarrow$ largest ΔE $\therefore n=\infty \rightarrow n=3$

$$\Delta E = E_f - E_i = -R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) = -R_H\left(\frac{1}{3^2} - \frac{1}{\infty^2}\right)$$

$$= -R_H\left(\frac{1}{9}\right) = -2.18\times10^{-18}\,J \times\left(\frac{1}{9}\right) = \underline{\underline{-2.42\times10^{-19}\,J}}$$

(We have a minus sign b/c the system loses energy.)

b. photon energy $E = h\nu = \dfrac{hc}{\lambda}$

$$\lambda = \frac{hc}{\Delta E} = \frac{(6.63\times10^{-34}\,Js)(3.00\times10^{8}\,m\,s^{-1})}{2.42\times10^{-19}\,J}$$

$$= 8.21\times10^{-7}\,m \;\left(\times\frac{10^9\,nm}{1\,m}\right)$$

$$= 8.21\times10^{2}\,nm = \underline{\underline{821\,nm}}$$

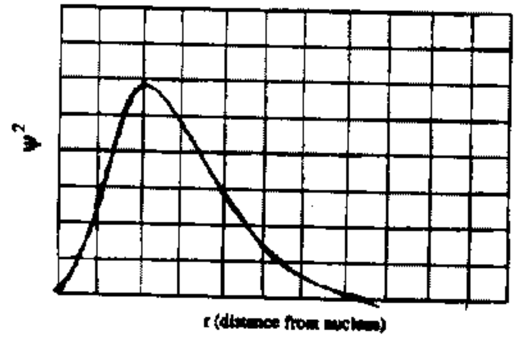
c. This is just slightly longer than the λ for red light.

$\therefore$ $\underline{\underline{\text{just in the infrared}}}$

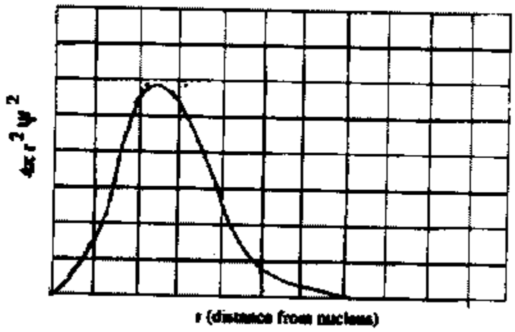
8 "Point Probability"

"Radial Probability"

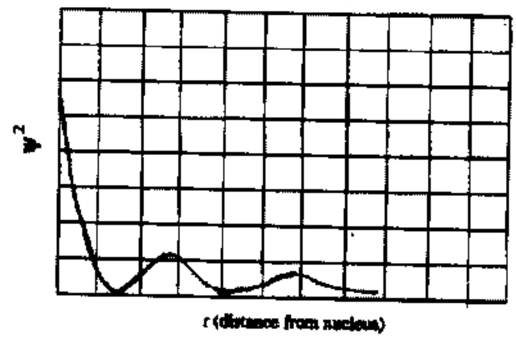
2p



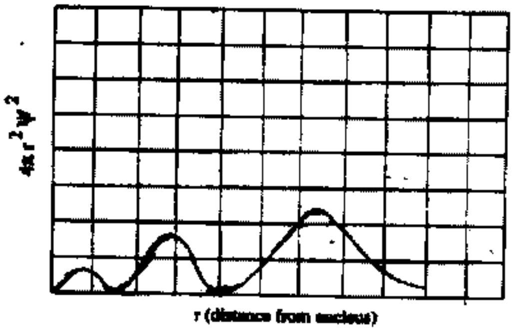
2p



3s

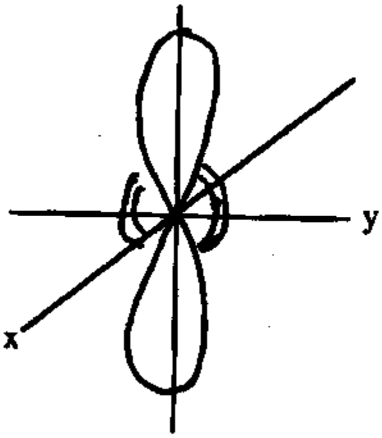


3s

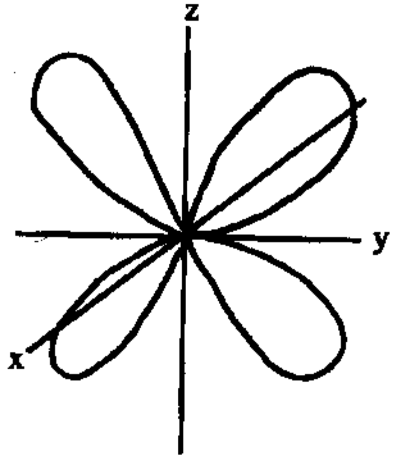


9. Orbital Diagrams

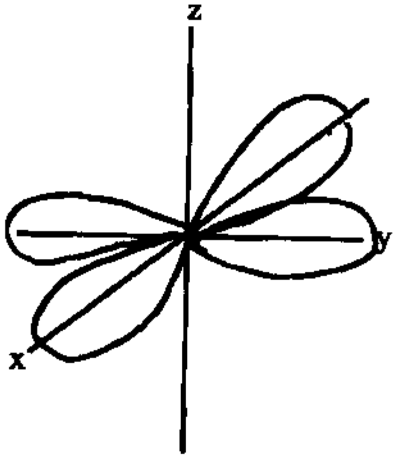
$3d_{z^2}$



$3d_{yz}$



$3d_{x^2-y^2}$



10. a. V: $[Ar]\,4s^2\,3d^3$; Cu : $[Ar]\,4s^1\,3d^{10}$

b. Cr , $[Ar]\,4s^1\,3d^5$; $[Ar]\ \underset{4s}{\underline{1}}\ \ \underset{3d}{\underline{1}\ \underline{1}\ \underline{1}\ \underline{1}\ \underline{1}}$

∴ 6 unpaired e^-

Cr^{3+}: $[Ar]\,3d^3$, $[Ar]\ \underset{3d}{\underline{1}\ \underline{1}\ \underline{1}\ \underline{\ \ }\ \underline{\ \ }}$

∴ 3 unpaired e^-

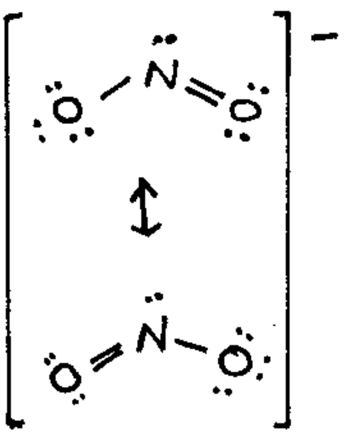
c. i. Se^{2-} ; ii : Co^{3+}

d. $Mg^{2+} < Na^+ < F^- < Br^-$

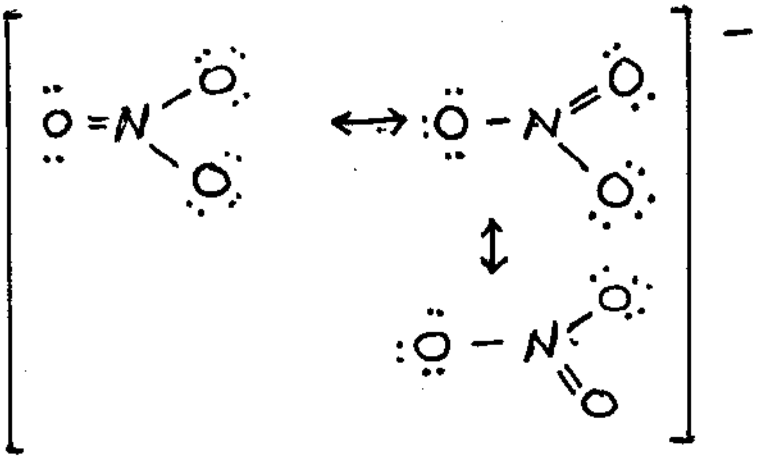
e. Na < Se < Br < F

11. Both anions exist as resonance hybrids

NO_2^-



NO_3^-



NO_2^- : both resonance structures contribute equally; each N, O bond is 50% single & 50% double.

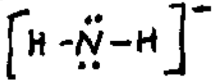
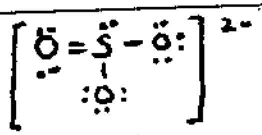
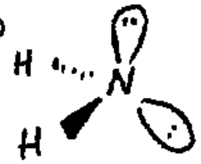
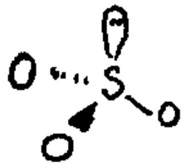
We estimate that the bond length will be the average of single & double N, O bond length ∴ $\underline{\underline{\sim\ 132\ pm}}$

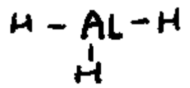
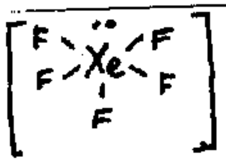
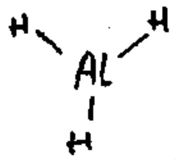
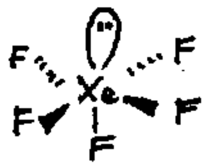
11. cont$^{\underline{d}}$

NO_3^- : the 3 resonance structures contribute equally ; each N,O bond is $\frac{2}{3}$ single & $\frac{1}{3}$ double ; we take the weighted average (closer to single than double bond) and estimate

∴ ~ $\underline{\underline{136 \text{ pm}}}$

12.

	NH_2^-		SO_3^{2-}
(a)		(a)	
(b)	 tetrahedal	(b)	 tetrahedal
(c)	bent	(c)	trigonal pyramidal
(d)	sp^3	(d)	not required

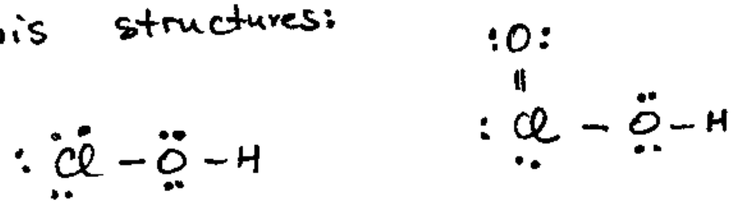
	AlH_3		XeF_5^+
(a)		(a)	
(b)	 trigonal planar	(b)	 octahedral
(c)	trigonal planar	(c)	square pyramidal
(d)	sp^2	(d)	sp^3d^2

13. a. Remove H^+ from each acid:

∴ ClO^- & ClO_2^-

b. the stronger base will have the weaker conj. acid; therefore we'll examine the acids for strength.

Lewis structures:



HClO is weaker b/c it has no terminal O attached to the central atom; polarizes O-H bond less.

∴ ClO^- is a stronger base than ClO_2^-.

---

14. Main Point:

The states of matter a substance can assume depends on the pressure. At normal pressures (~ 1 atm), CO_2 can exist only as solid and gas. If we allow the pressure to increase above the triple point pressure, all 3 states of matter can be observed: Solid, liquid & gas

15. a. degenerate: refers to different orbitals that have the same energy

b. α particle: produced by radioactive materials; consist of He^{2+} ions

c. isoelectronic: refers to different atomic species that have the same number of e^-.

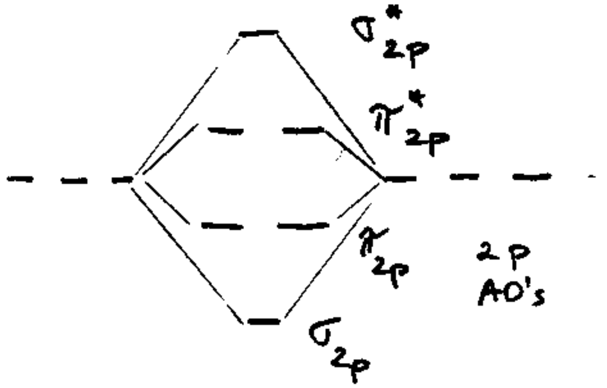
d. molecular solid: a solid in which the molecules/atoms are held together by "weak" intermolecular forces (such as dipole - dipole, London dispersion forces) but not by ionic or covalent bonds

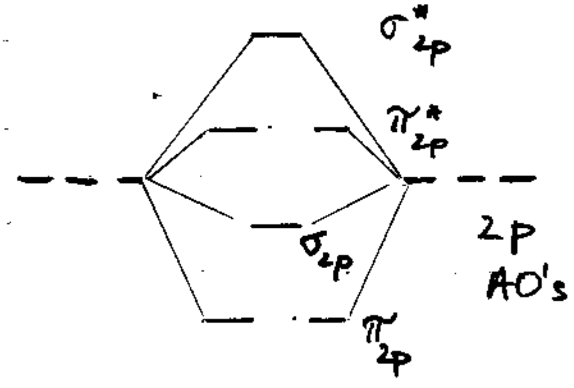
e. discharge tube: a tube filled with a gas (generally) at low pressure and fitted with 2 electrodes. A high voltage is applied which causes emission of electrons from the cathode. The stream of electrons causes electronic transitions in the gas molecules to higher energy levels. Upon return to the ground states emission of electromagnetic radiation is commonly observed.

15.f. diffusion : refers to molecular movement in space that is occupied by other molecules

g. elastic collision : as used in the kinetic molecular theory: collisions between molecular species that result in exchange of kinetic energy, but in no "permanent" changes in potential energy ("deformations").

16. We will ignore the $\sigma_{1s}/\sigma_{1s}^*$ and $\sigma_{2s}/\sigma_{2s}^*$ MO's since they generally cancel as far as bonding effects are concerned.





Notes : · not to scale

· the question should have stated that we are dealing with diatomic species.

"expected"	"modified"
applies to O, F, Ne	applies to B, C, N

17. The gage pressure in the tire is

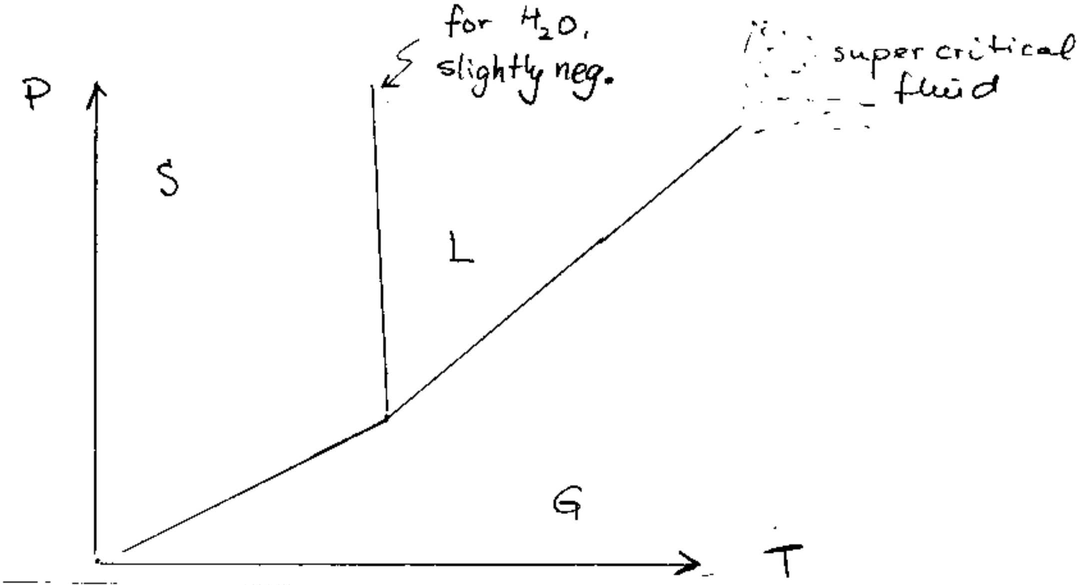
$$32 \text{ psi} \times \frac{1 \text{ atm}}{14.7 \text{ psi}} \times \frac{101.3 \text{ kPa}}{1 \text{ atm}} = 221 \text{ kPa}$$

We have to add the atmospheric pressure.

On average, the Edmonton atmospheric pressure is about 91 kPa.

∴ Absolute Tire Pressure = 221 kPa + 91 kPa = 312 kPa

18.



The question sounds innocent, but is quite Loaded. PD's apply strictly only to systems that are in equilibrium. All three phases are present but we are not at the triple point because we are not at equilibrium (heat exchange take place etc. etc.) In order to reach the triple point, external gases (air) and dissolved matter should be removed and the systems should be closed & insulated. Nevertheless, we can estimate that the temp. and vapor pressure must be close to the triple point temp. & pressure.