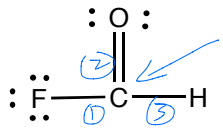
Exam 1a
Chem 1142
Spring 2011

Name:_____

MULTIPLE CHOICE. [3 pts ea.] Choose the best response on the scantron sheet. [**33 pts total.**]

Q1. What type of hybrid orbital is required on the central carbon atom in the following molecule:



3 repulsions
120°
trigonal planar

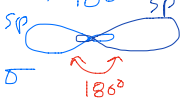
#rep	2	3	4	5	6
hybrid	sp	sp^2	sp^3	sp^3d	sp^3d^2

a) sp b) sp^2 c) sp^3 d) sp^3d e) sp^3d^2

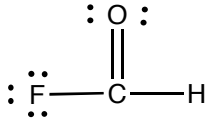
Q2. The angle between sp hybrid orbitals is:

sp → linear e⁻ geom

a) 180° b) 120° c) 109.5° d) 90° e) 60° ⇒ 180°



Q3. The number of sigma and pi bonds in the following molecule is:

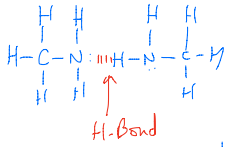


First bond between 2 atoms is always σ
Other bonds are always π.

a) 1 σ, 3 π b) 2 σ, 2 π c) 3 σ, 1 π d) 4 σ e) 4 π

Q4. Which of the following molecules are capable of hydrogen bonding among themselves:

a) C_2H_6 b) HI c) KF d) BeH_2 e) CH_3NH_2

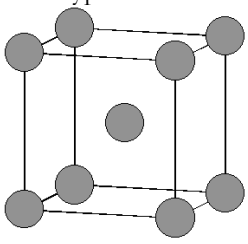


N: = H-Bond acceptor
N–H = H-Bond donor

Q5. Which of the following substances forms an amorphous crystal in the solid state:

a) Ice b) Glass c) Quartz d) Graphite e) Ammonia

Q6. Which type of unit cell is shown below?



a) Simple cubic b) Face-centered Cubic c) Body-centered cubic
d) Tetragonal e) Monoclinic

Q7. Which of the following substances would be most likely to dissolve in CCl_4?

Like-dissolves-like
Both Br_2 + CCl_4 are non-polar

a) $NaNO_3$ b) HCl c) NH_3 d) CH_3OH e) Br_2

Q8. Which of the following aqueous solutions would have the greatest boiling point?

a) 0.100 m $C_6H_{12}O_6$ b) 0.080 m NaCl c) 0.070 m $CaCl_2$
d) 0.050 m $NaC_2H_3O_2$ e) pure water

$\Delta T_b = i \cdot m \cdot K_b$

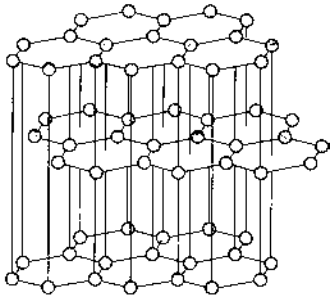
$\propto i \cdot m$

van't Hoff factor → # particles (ions) each formula unit breaks apart into

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$, $i = 3$

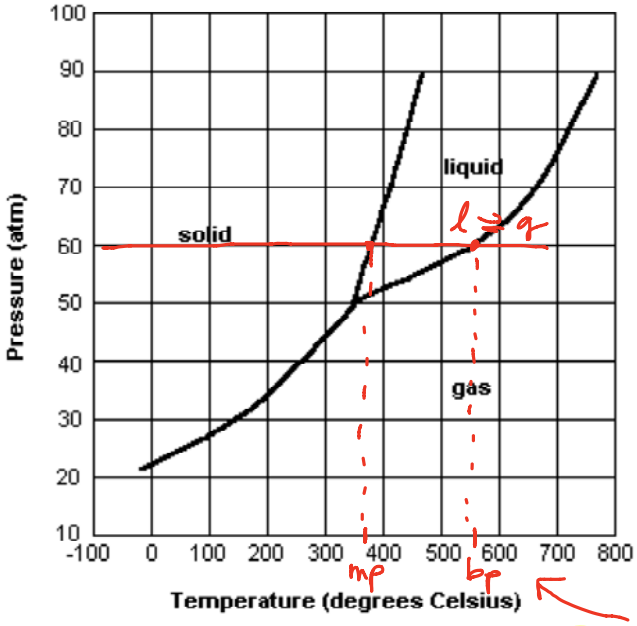
$i \cdot m = 3 \times 0.070\,m = 0.21\,m$

Q9. Which substance has the following solid-state structure?



a) Graphite b) Quartz c) Diamond d) Glass e) Sodium

Q10. The phase diagram for an unknown substance is show below. Based on this phase diagram, what is the boiling point of this substance at 60 atm?



bp: $l \rightarrow g$

a) 60 °C b) 350 °C c) 370 °C d) 550 °C e) 760 °C

Q11. The Henry's law constant for ethanol in water is 160 M·atm^{-1} at 37 °C. What is the predicted partial pressure of ethanol vapor above an aqueous sample of ethanol whose molar concentration is 1.7 x 10^{-2} M?

(Note: this corresponds to a Blood Alcohol Concentration of 0.08, which is the legal definition of intoxication.)

a) 1.1 x 10^{-4} atm b) 9400 atm c) 5.5 x 10^{-5} atm d) 2.72 atm e) 1.7 x 10^{-2} atm

Henry: $C = k \cdot P$ (Henry's Law Constant, depends on gas, solvent, T)

C: conc of dissolved gas; P: pressure of gas

$$\Rightarrow P = \frac{C}{k} = \frac{1.7 \times 10^{-2}\ M}{160\ M \cdot atm^{-1}} = 1.1 \times 10^{-4}\ atm$$

Short Response.

Show ALL work to receive credit.

Q12. [10 pts.] Calculate the % by mass, the molarity, and the molality of a solution made by mixing 12.0 g NaCl (solute) with 139.0 g H_2O (solvent), such that its final volume is 141.0 mL. Show ALL work.

$\%_{(w/w)} = \frac{12.0\text{ g solute}}{(12.0 + 139.0)\text{ g solution}} \times 100 = 7.95\%_{(w/w)}$ NaCl

$\text{Molar conc} = \frac{\#\text{mol NaCl}}{\#\text{L soln}} = \frac{0.2053\text{ mol}}{0.1410\text{ L}} = 1.46\text{ M NaCl}$

$12.0\text{ g NaCl} \left| \frac{1\text{ mol NaCl}}{58.44\text{ g NaCl}} \right. = 0.2053\text{ mol NaCl}$

$\text{Molal conc} = \frac{\#\text{mol NaCl}}{\#\text{kg } H_2O} = \frac{0.2053\text{ mol}}{0.1390\text{ kg}} = 1.48\text{ m NaCl}$

Comment: For dilute aq. soln's, Molar conc $\approx$ Molal conc.

Q13. [2 pts.] The greater the molar heat of vaporization of a liquid, the greater is vapor pressure. True or false?

$X(l) \rightarrow X(g)$; ΔH_{vap} - If $\Delta H_{vap}\uparrow$, takes more E to convert $l \rightarrow g$ $\Rightarrow$ Will have lower vp, since less gas will form.

- ΔH_{vap} is a measure of IMFs.

Q14. [5 pts.] What is the osmotic pressure of 0.100 M $Ca(NO_3)_2$(aq) at 37 °C?

$37 + 273.15 = 310.\text{K}$

$Ca(NO_3)_2(aq) \rightarrow Ca^{2+}(aq) + 2NO_3^-(aq)$

If no ion-pairing, i=3

$\Pi = i \cdot M \cdot R \cdot T$

$= 3 \times 0.100 \frac{\text{mol}}{\text{L}} \times 0.08206 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 310.\text{K}$

$= \boxed{7.63\text{ atm}}$

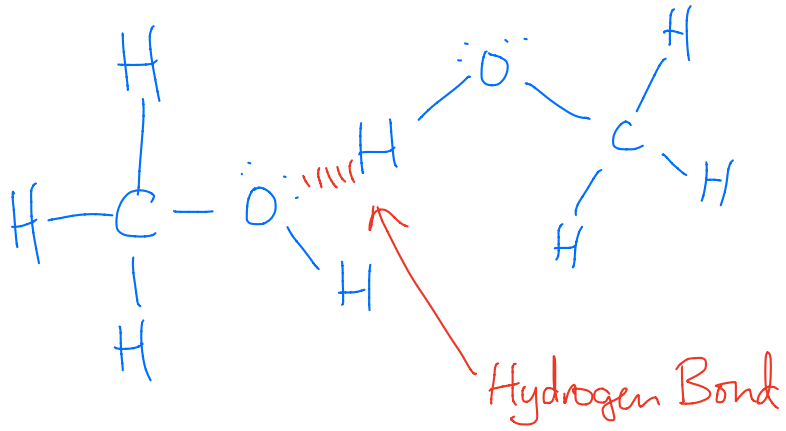
Q15. [3 pts.] Under what circumstance will a gas not obey Henry's law? Give an example.

If the gas reacts w/ solvent, rather than just dissolving in it.

ex: $NH_3(g)$ in $H_2O(l)$

$NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

Q16. [8 pts.] Draw a diagram showing the formation of hydrogen bonds between molecules of CH_3OH. Clearly label the location of the hydrogen bonds in your diagram!



Q17. [8 pts.] EXPLAIN which of the following substances would have the GREATEST vapor pressure.

$CH_3CH_2NH_2$
IMF: London, d-d, H-Bonding

$CH_3CH_2CH_3$
IMF: London

CH_3CH_2Br
IMF: London, d-d

GREATEST VP = Weakest IMFs
$CH_3CH_2NH_2$ has (relatively) strong H-Bonding ⇒ Low VP
CH_3CH_2Br has d-d (weak), but intermediate London since has a lot of e⁻s coming from Br-atom
$CH_3CH_2CH_3$ only has London, and much fewer e⁻s than CH_3CH_2Br ⇒ weakest IMF
⇒ GREATEST VP!

Q18. [8 pts.] If the osmotic pressure of 175. mL of an aqueous solution at 305 K containing 0.0341 g of solute is 1.31 x 10^{-3} atm, then what is the molar mass of the solute? The solute is a non-electrolyte.

$\Pi = iMRT = MRT$ (i=1, since solute is non-electrolyte)

$M = \frac{\Pi}{RT} = \frac{1.31\times10^{-3}\ atm}{0.08206\ \frac{atm\cdot L}{mol\cdot K}\times 305\ K}$

$= 5.234\times10^{-5}\ \frac{mol}{L}$

$M = \frac{\#g}{\#mol} = \frac{0.0341\ g}{9.1596\times10^{-6}\ mol} = \boxed{3720\ g/mol}$

#mol? $175\ mL \left|\frac{1\ L}{1000\ mL}\right| \left|\frac{5.234\times10^{-5}\ mol}{1\ L}\right| = 9.1596\times10^{-6}\ mol$

Q19. [3 pts.] Why are metals good conductors of electricity?

In metallic crystal, valence e⁻s are fully delocalized, forming an "electron sea". These free e⁻s are what causes metals to be good conductors.

Old-Time Chemistry Corner

Q20. [10 pts.] Write formulas for the following substances:

i) sodium carbonate	Na_2CO_3	Na^+ CO_3^{2-}
ii) ammonium bromide	NH_4Br	NH_4^+ Br^-
iii) iron(III) nitrate	$Fe(NO_3)_3$	Fe^{3+} NO_3^-
iv) heptabromine octoxide	Br_7O_8	
v) calcium sulfite dihydrate	$CaSO_3 \cdot 2H_2O$	Ca^{2+} SO_3^{2-}

Q21. [10 pts.] Predict the MOLECULAR geometry of SF_4. Your answer should include a valid Lewis structure, and a sketch of the molecular geometry including approximate bond angles.

Explain whether SF_4 is polar or non-polar.

SF_4

$6+7\times4=34e^-$

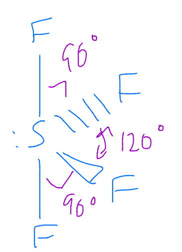
Lewis:

34
− 8 (bonds)
− 24 (lp on F)
2 e⁻
− 2 e⁻ (lp on S)
0

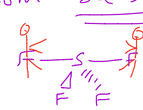
VSEPR

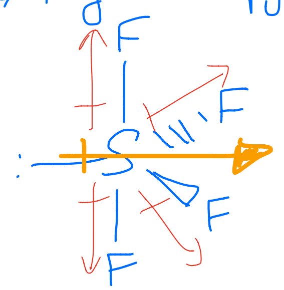
5 - repulsions around S

⇒ trigonal bi-pyramidal.



geom = see-saw





overall dipole ≠ 0

⇒ POLAR

⟶ = Bond dipole

lp goes on equatorial position (only 2 reps @ 90°)

Useful Information

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	18
1 H 1.01	2											13	14	15	16	17	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba* 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra** [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
**	89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]

1 atm = 101,325 Pa = 760 mmHg = 760 torr

$R = 0.08206$ L·atm/mol·K

$R = 8.314$ J/mol·K

$(p + an^2/V^2)(V - nb) = nRT$

$pV = nRT$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$pM = dRT$

$q = ms\Delta t = C\Delta t$

$\Delta H^\circ_{rxn} = \Sigma n\Delta H_f^\circ(\text{products}) - \Sigma m\Delta H_f^\circ(\text{reactants})$

$E = h\nu$

$c = \nu\lambda$

$N_A = 6.022 \times 10^{23}$ mol^{-1}

$c = 3.00 \times 10^8$ m/s

$h = 6.626 \times 10^{-34}$ J·s

$$E = \frac{hc}{\lambda}$$

$E_n = -R_H\,(1/n^2)$

$R_H = 2.18 \times 10^{-18}$ J

$M_1V_1 = M_2V_2$

$\Delta T_b = ik_bm$

$\Delta T_f = ik_fm$

$\Pi = iMRT$

$c = kP$