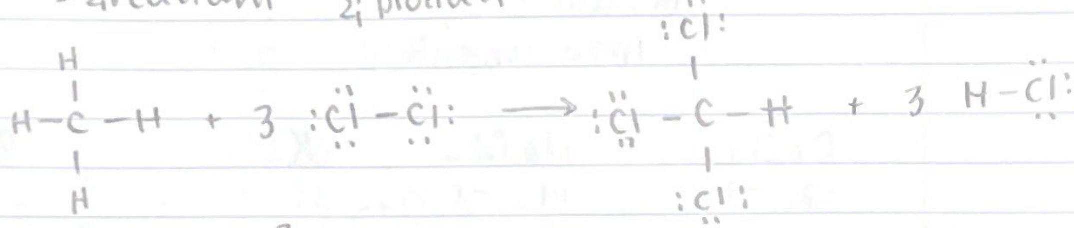
CHM2045 EXAM3 Solutions

1) $CH_4 + 3Cl_2 \rightarrow CHCl_3 + 3HCl$

ΔH = bond broken − bond form
= Σ reactant − Σ product



4x C−H   3 x Cl−Cl   3x C−Cl + 3xH−Cl
1X C−H

$\Delta H = [4(C-H) + 3(Cl-Cl)] - [3(C-Cl) + C-H + 3(H-Cl)]$
$= [4(413) + 3(243)] - [3(-339) + 413 + 3(-427)]$
$= 2381 - -2020$

ΔH = 4401 kJ/mol (C)

2) single longest & weakest
triple shortest & strongest
(D)

S−S < S=S < S≡S

3) H is smallest ion
↑ down, larger size, longer bond
column

H < F < Cl < I (size)
H−H < H−F < H−Cl < H−I (C)

4) Lattice energy based on Columb law $\frac{|cation||anion|}{distance}$

* charge product overpower distance (based on atomic size)
(more important

	$CaCl_2$	$NaCl$	KCl	$BaCl_2$
	+2 −1	+1 −1	+1 −1	+2 −1
charge	2	1	1	2

~~size~~

$CaCl_2$ & $BaCl_2$ > $NaCl$ & KCl

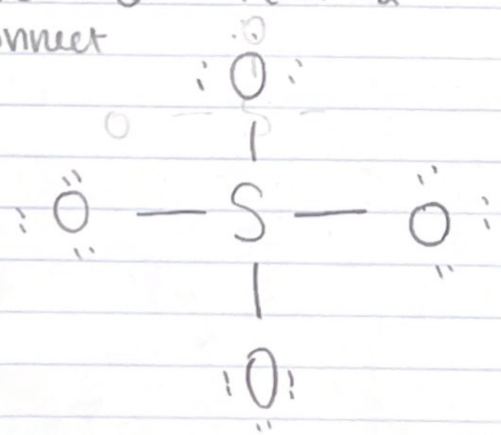
$CaCl_2$ vs $BaCl_2$
on size
smaller size
larger lattice
↓
Ba > Ca
so $CaCl_2$ > $BaCl_2$ lattice

$NaCl$ vs KCl
based on size
smaller → greater L.E.
K > Na so $NaCl$ > KCl L.E.

KCl < $NaCl$ < $BaCl_2$ < $CaCl_2$ (D)

5) SO_4^{2-}

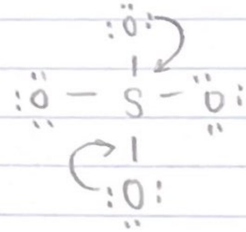
1) # ve⁻ 6 + 4(6) + 2 = 32 valence e⁻
2) connect



32
− 8
24

3) Formal charges (normally don't want > 1

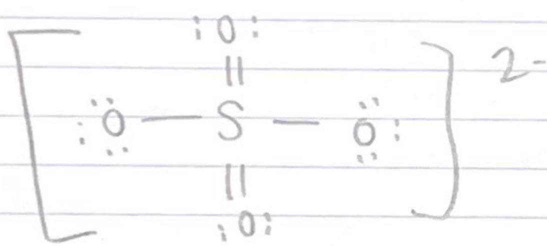
5 cont'd)



formal charge = ve - (dot + line)

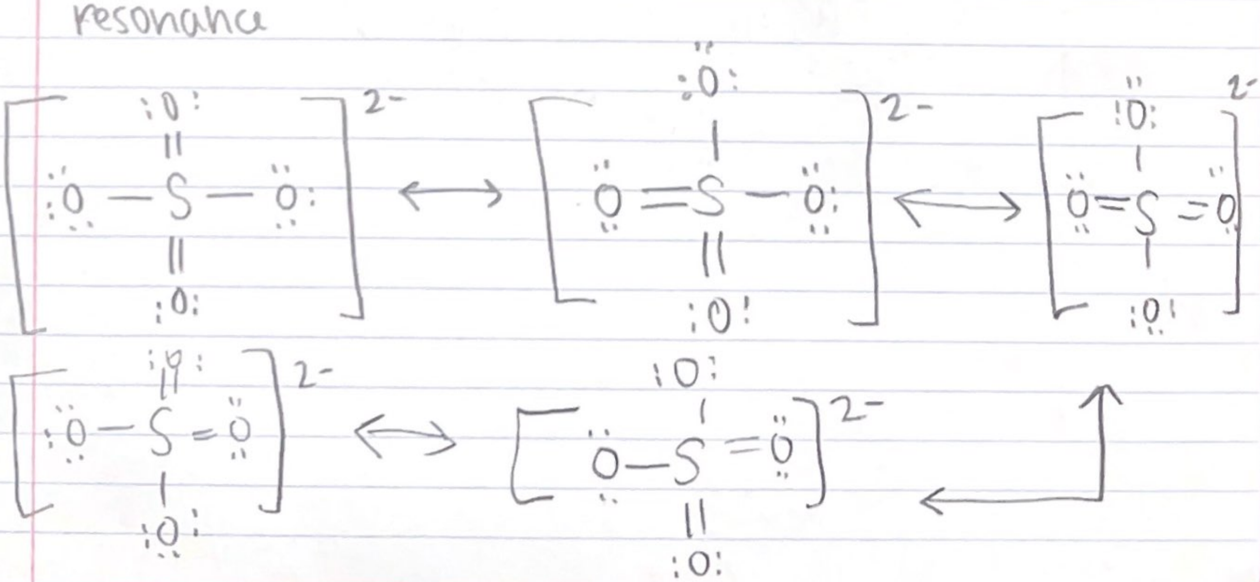
F.C S = 6 - 4 = +2
F.C O = 6 - (6+1) = -1

S can hold expanded octet



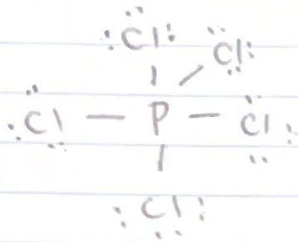
S FC = 6 - 4 = 0 ✓
O double FC = 6 - (4+2) = 0 ✓
O single FC = 6 - (6+1) = -1

resonance



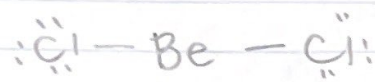
6)

I



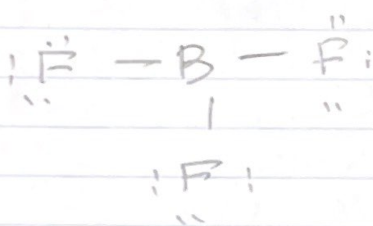
P 10 e^- ✓

II



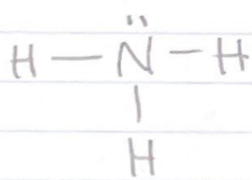
Be 4 e^- ✓

III



B 6 e^- ✓

IV



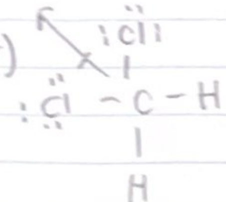
N 8 e^- ✓

V

O 8 e^- ✓

I, II, III (A)

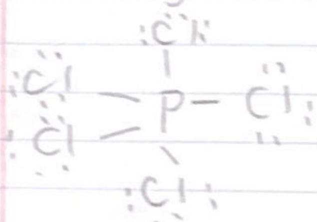
7)



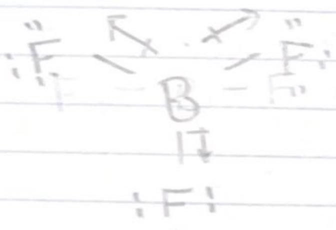
✓ polar

(A)

PCl_5

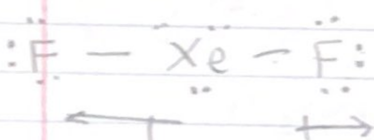


trig bipyramid → nonpolar



nonpolar
trigonal
planar

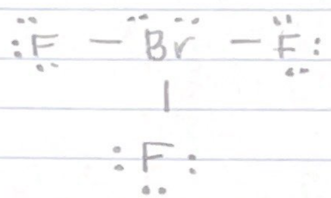
all dipoles cancel



linear nonpolar

8.

a) BrF_3 $7 + 3(7) = 28$ valence e^-



FC Br $7 - (3+4) = 0$ ✓

F $7 - (6+1) = 0$ ✓

e^- geo : 5 electron group → trigonal bipyramidal

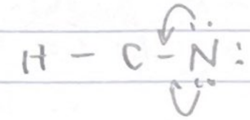
molecular geo : 3 bond 2 lone pair

T-shaped

<u>bond angles</u> axial - 120°

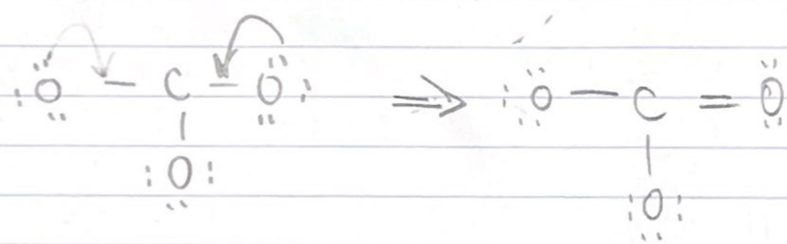
equatorial - 180°

8b) HCN   ve = 1 + 4 + 5 = 10



H − C ≡ N: e⁻ geo: linear
mol. geo: linear
bond angles: 180°

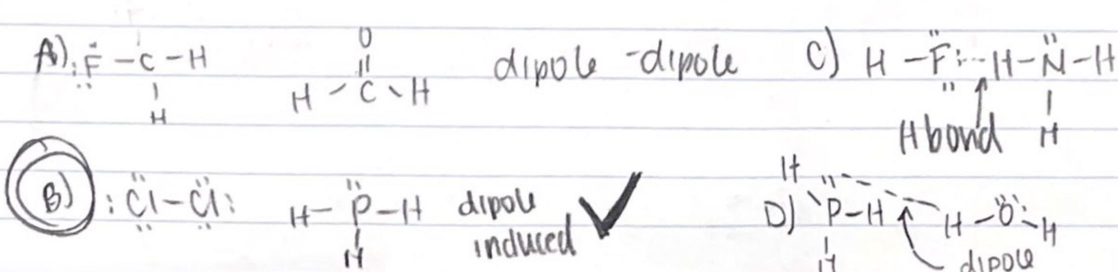
8c CO_3^{2-} ve   4 + 3(6) + 2 = 24



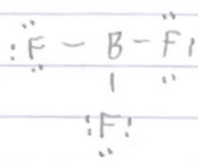
FC C   4 − 4 = 0 ✓
O double   6 − (2+4) = 0 ✓
O single   6 − (6+1) = −1 (2 since −2 overall charge)
(resonance structures not pictured)

e⁻ geo: trigonal planar
mol geo: trigonal planar
bond angle: 120°

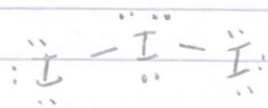
9)

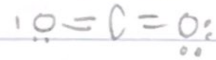


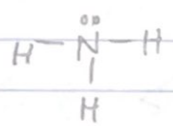
10)

a)  sp^2

(A)

b)  sp^3d

c)  sp

d)  sp^3

11

		σ_{2s}	σ^*_{2s}	σ_{2px}	π_{2py}	π_{2pz}	π^*_{2py}	π^*_{2pz}	σ^*_{2px}	
12ve	O_2	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑		✓
11ve	O_2^+	↑↓	↑↓	↑↓	↑↓	↑↓	↑			✓
13	O_2^-	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑		✓

(D)

12) bond length inverse to bond strength direct to bond order

↑ bond order ↓ bond length $B.O = \frac{\text{bond} - \text{anti bond}}{2}$

V.e⁻		σ_{2s}	σ^*_{2s}	π_{2py}	π_{2pz}	σ_{2px}	π^*_{2py} π^*_{2pz} σ^*_{2px}
6	C_2^{2+}	↑↓	↑↓	↑	↑		$4-2/2 = 1$
8	C_2	↑↓	↑↓	↑↓	↑↓		$6-2/2 = 2$
10	C_2^{2-}	↑↓	↑↓	↑↓	↑↓	↑↓	$8-2/2 = 3$
9	C_2^-	↑↓	↑↓	↑↓	↑↓	↑	$7-2/2 = 2.5$

B.O $C_2^{2+} < C_2 < C_2^- < C_2^{2-}$

length $C_2^{2-} < C_2^- < C_2 < C_2^{2+}$

C_2^{2+} (A)

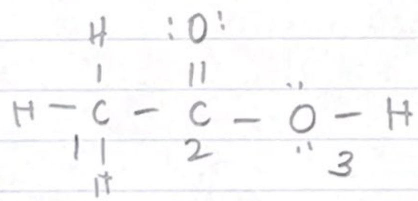
13) all single σ

each double bond 1 π 19σ

5 double 5 π

(B)

14)



1, sp^3, 2. sp^2, 3. sp^3 (A)

15 ↑IMF ↑BP

I) CH_2Br_2 dipole - dipole
II) CH_3CH_2OH H bond
III) F_2 dispersion } based on molar mass
IV) CH_4 dispersion }

IV < III < I < II (B)

16) ↑IMF ↓VP

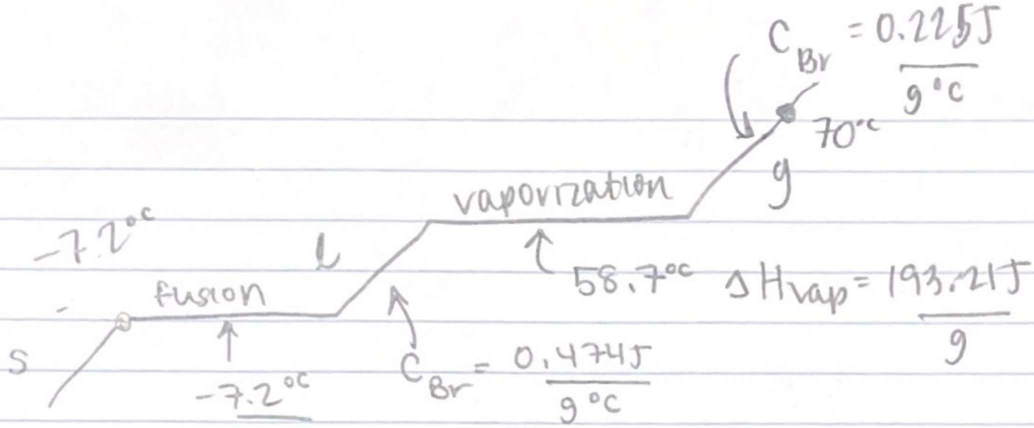
a) CH_4 dispersion ← (A)
b) H_2O H bond
c) CH_2Cl_2 dipole
d) NH_3 ~~H~~bond in

17) ↑ IMF ↑Viscosity

a) BF_3 dipole induced (dispersion)
b) CH_2I_2 dipole
c) NH_3 H bond ← highest (C)
d CH_4 dispersion

18) a) ↑T ↓viscosity
b) ↑VP ↓ IMF (C)
c) T
d) ↑ST ↓T

19)



$\Delta H_{fusion} = \frac{66.15\,J}{g}$

1) ΔHfusion energy
2) energy of liquid from -7.2 - 58.7°c
3) ΔHvaporization energy
4) energy of gas from 58.7°C — 70°c

1) $Q_L = mass \cdot \Delta H_{fus}$
$= 10.0g\left(\frac{66.15J}{g}\right) = \underline{661.5J}$

2) $q_2 = mC_2\Delta T \quad = 10g\left(\frac{0.474J}{g°c}\right)(65.9°c) = \underline{312.37J}$
$C = 0.474\,J/g°c$
$\Delta T = 58.7°c - (-7.2°c) = 65.9°c$

take most E

3) $q_3 = mass \cdot \Delta H_{vap} = 10g\left(\frac{193.21J}{g}\right) = \underline{1932.1J}$

4) $q_4 = mC_{gas}\Delta T \quad 10g\left(\frac{.225J}{g°c}\right)(11.3°c)$
$C = 0.225J/g°c$
$\Delta T = 70 - 58.7°c \quad = \underline{25.43J}$

most energy to vaporize liquid to gas
total $q = q_1 + q_2 + q_3 + q_4 = 661.5 + 312.37 + 1932.1 + 25.43$
$= 2931.4J$