PART I *(39 pts.)* **Multiple Choice.** Choose one correct answer for each of the following 13 questions and mark it on both the attached answer sheet and on the exam. Only the answer sheet will be graded. Each multiple question is worth three (3) points.

answer key for DAHL-variation is on page 9

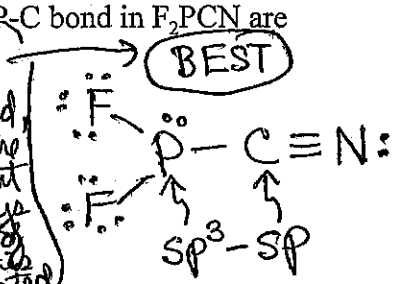
1. The hybrid orbitals utilized for the P-C bond in F_2PCN are

BOTH ACCEPTED

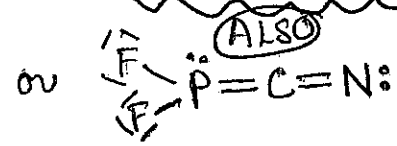
A. $P(sp^3)$ - $C(sp^2)$
B. $P(sp^2)$ - $C(sp)$
C. $P(sp^3)$ - $C(sp)$
D. $P(sp^2)$ - $C(sp^2)$
E. none of the above

if FORMAL CHARGES are considered, this structure is better, but the other one is also accepted. all "rules" of Chem 103 are to be followed

BEST



ALSO



2. A real gas mostly closely approaches ideal behavior at: ~~high T~~, low P, high T

A. 1.0 atm and 273 K
B. 10.0 atm and 546 K
C. 10.0 atm and 273 K
D. 0.5 atm and 273 K
E. 0.5 atm and 546 K

3. Sulfur dioxide gas, $SO_2(g)$, effuses through a porous membrane at a root-mean-square speed of 400 m/s. If an unknown gas at the same temperature effuses through the membrane at 284 m/s, determine the molecular weight of the unknown gas.

32+32

A. 45 g/mole
B. 90 g/mole
C. 127 g/mole
D. 32 g/mole
E. none of the above

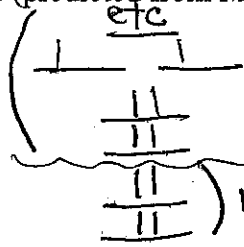
$$\frac{\text{gas}\ \frac{1}{2}Muu}{SO_2\ \frac{1}{2}Muu} = \frac{\frac{3}{2}RT\ 1}{\frac{3}{2}RT\ 1}$$

$$\frac{M(284)^2}{64(400)^2} = \frac{1}{1}$$

$$M = 127$$

4. The diatomic species with the smallest bond order is (predicted from MO theory)

A. only Li_2^+ — 5 — $\frac{1}{2}(+1-0)=\frac{1}{2}$
B. only Be_2^{2-} — $8+2=10$ — $\frac{1}{2}(+4-2)=1$
C. only Li_2^- — $6+1=7$ — $\frac{1}{2}(+2-1)=\frac{1}{2}$
D. only Be_2^{2+} — $8-2=6$ — $\frac{1}{2}(+2-0)=1$
E. more than one of the above answers



net bonds $= \frac{+2-2}{2} = 0$

5. If 20.4g of Ar(g) are mixed with 1.36g of He(g) in a flask at a given temperature, the total pressure in the flask is found to be 5.0 atmospheres. Determine the partial pressure of He(g) in this flask. Atomic weights are 39.95 g/mol for Ar and 4.00 g/mol for He.

A. 2.0 atm
B. 0.85 atm
C. 3.0 atm
D. 4.15 atm
E. none of the above

$$\frac{He \rightarrow PV}{TOT \rightarrow PV} = \frac{nRT}{nRT}$$

$$\frac{P_{He}}{5.0\,atm} = \frac{.34\,mol}{.85\,mol}$$

$$P_{He} = 2.0\,atm$$

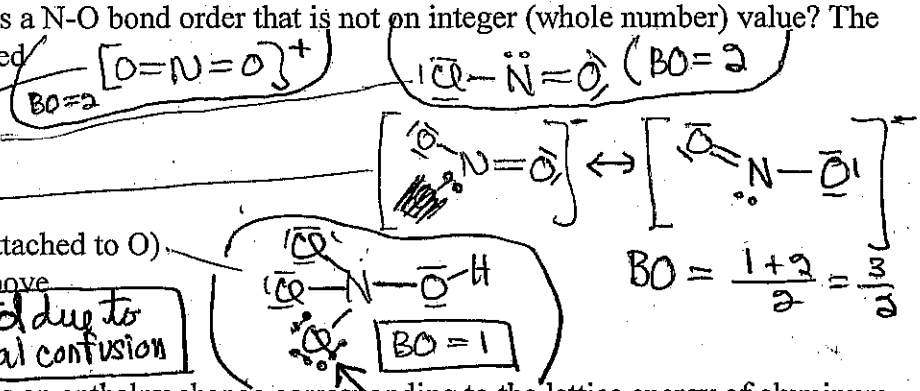
$20.4\,g\,Ar\left(\frac{1\,mol\,Ar}{39.95\,g\,Ar}\right) = .51\,mol\,Ar$

$1.36\,g\,He\left(\frac{1\,mol\,He}{4.00\,g\,He}\right) = .34\,mol\,He$

$.85\,mol$ TOTAL

6. Which of the following has a N-O bond order that is not on integer (whole number) value? The central N atom is underlined

A. only $\underline{NO_2}^+$
B. only Cl $\underline{NO}$
C. only $\underline{NO_2}^-$
D. only $Cl_3\underline{N}OH$ (H is attached to O)
E. two or more of the above



also accepted due to typographical confusion

7. Which of the following has an enthalpy change corresponding to the lattice energy of aluminum fluoride?

A. $Al^{3+}(g) + 3F^-(g) \rightarrow AlF_3(g)$
B. $Al(g) + 3/2\ F_2(g) \rightarrow AlF_3(s)$
C. $Al(s) + 3/2\ F_2(g) \rightarrow AlF_3(s)$
D. $Al^{3+}(g) + 3F^-(g) \rightarrow AlF_3(s)$ (is all OK)
E. none of the above

IN REALITY, THIS STRUCTURE DOES NOT OCCUR

this was a typographical error, should have been Cl_2NOH but as is the only possible structure according to "rules" of Chem 103 puts 9 e's around Cl, which can have 8, 10 or 12 (or 9?) giving N–O a single bond

8. A possible chemical of a gas with a gas density of 1.82 g/L at a pressure of 1064 torr and 27°C is:

A. $CH_4(g) \rightarrow 16.0\ g/mol$
B. $CO_2(g) \rightarrow 44.0\ g/mol$
C. $CO(g) \rightarrow 28.0\ g/mol$
D. $O_2(g) \rightarrow 32.0\ g/mol$ (MATCH)
E. none of the above

$$PM = dRT$$
$$\left(\frac{1064}{760}\right) M = \left(1.82\frac{g}{L}\right)\left(.0821\frac{L\,atm}{g\,K}\right)(27+273)$$
$$M = 32.0$$

9. Which of the following boards has the smallest polar character?

A. (N-O)
B. (N-P)
C. N-N (POLARITY=0)
D. ~~N-As~~
E. ~~N-Li~~

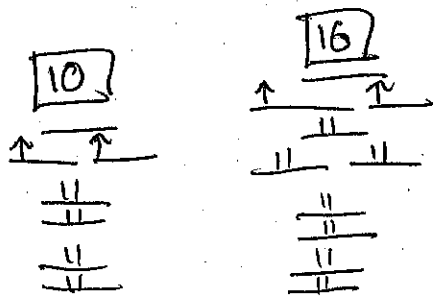
O
N
P
As
Li

ELECTRO-NEGATIVITY

THIS was a GIVEAWAY!

10. Which of the above species is paramagnetic? use MO not VB

A. only C_2^{2-} 12+2=14 — dia
B. only N_2^{2+} 14−2=12 — dia
C. only C_2^{2+} 12−2=10 — PARA
D. only N_2^{2-} 14+2=16 — PARA
(E.) more than one of the above



11. Which of the following is not a valid Lewis dot structure for N_2O?

5+5+6 = ~~20~~ 16 vls

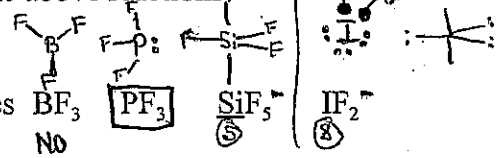
	vls?	octets?
A. :N≡N−O:	16	Ok
B. N=N=O	16	Ok
C. :N≡N−O:	16	Ok
(D.) N=N=O (N: no)	16 — all Ok	middle N doesn't have 8 electrons around it

E. none of the above

12. Which one of the following is an exothermic process?

A. $S^-(g) + e^- \rightarrow S^{2-}(g)$ ~ ENDO
B. $K(s) \rightarrow K(g)$ ~ ENDO
C. $K(g) \rightarrow K^+(g) + e^-$ ~ ENDO
(D.) $S(g) + e^- \rightarrow S^-(g)$ ~ YES, is EXO
E. more than one of the above reactions

13. Of the following four species BF_3 PF_3 SiF_5^- IF_2^-



A. four have a molecular dipole moment
B. three have a molecular dipole moment
C. two have a molecular dipole moment
(D.) one has a molecular dipole moment
E. none has a molecular dipole moment

PART IIA *(31 pts.)*

1. (14 pts.)

A. The common name of $_{74}W$ — tungsten (formerly wolfram)

B. The common name of $_{86}Rn$ is — radon

C. The name of $Fe(ClO_3)_3$ is — iron(III) chlorate

D. The formula of osmium(III) sulfite is — $Os_2(SO_3)_3$

E. An ionic compound containing only calcium and nitrate ions is — $Ca(NO_3)_2$

F. A homonuclear diatomic species isoelectronic with a CF molecule is — N_2 or O_2^- (or B_2^{3-}, F_2^{3+}, etc.)

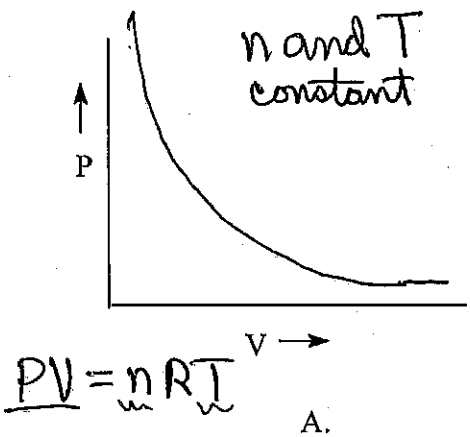
G. The mks units of one joule are — $\frac{kg \cdot m^2}{s^2}$ or $kg\ m^2\ s^{-2}$

$KE = \frac{1}{2}mv^2$

$(kg)\left(\frac{m}{s}\right)\left(\frac{m}{s}\right)$

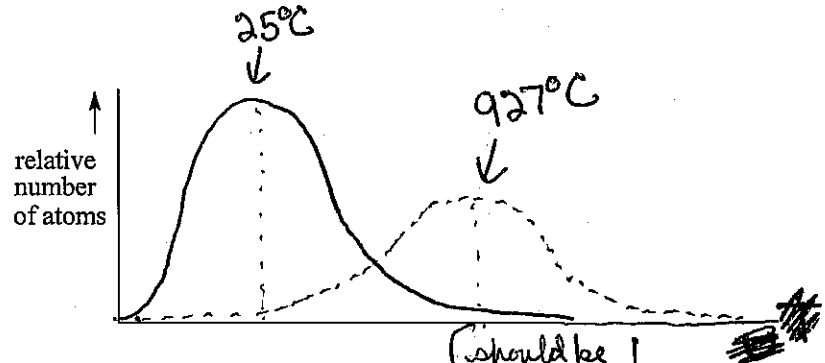
$\frac{kg \cdot m^2}{s^2}$

2. (8 pts.) For each of the following two graphs (A. and B.):



$PV = nRT$

A.



B.

should be TWICE as fast on rms-average, but we accepted any graph with further to right

A. Draw pressure versus volume curve for an ideal gas. State on graph the variables being held constant.

B. Draw two curves: solid-line curve of relative number of gaseous argon atoms (Ar, at.no.18) in one mole versus their atomic speeds at 25°C and dashed-line curve (on same graph) of relative number of gaseous argon atoms in one mole versus their atomic speeds at 927°C.

LOW SPEEDS

HIGH SPEEDS

$\frac{Mv^2}{Mv^2} = \frac{T}{T}$

$\frac{v^2}{v^2} = \frac{1200}{300}\ (=4)$ so v^2 is 4x larger, v is 2x larger

$28\frac{g}{mol}$ $44\frac{g}{mol}$

3. (9 pts.) Two equal masses (i.e, equal number of grams) of CO(g) and CO_2(g) are placed in separate containers of equal volume and at the same temperature.

A. Which gas has the lowest pressure? Briefly explain why. CO_2

$PV = nRT$

P increases as n increases, and $\frac{\text{grams}}{(\frac{\text{grams}}{\text{mole}})}$ is higher for CO because it has smaller $(\frac{\text{grams}}{\text{mole}})$ and is lower for CO_2 M^3

SAME KE

B. Which gas has the smallest average kinetic energy? Briefly explain why.

at same temperature, both have SAME kinetic energy,

$KE = \frac{3}{2}RT$

C. Which gas has the smallest root-mean-square speed? Briefly explain why.

$\frac{1}{2}Mv^2 = \frac{3}{2}RT$ CO_2

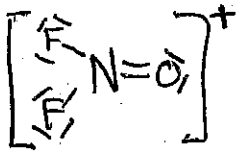
M and v^2 are inversely proportional, so largest M (CO_2 at .044 $\frac{kg}{mol}$) has smallest v

same for both

PART IIB (24 pts.)

1. (12 pts.) For each of the following species in which the central atom is underlined answer the following. Describe each geometry in **words** instead of only a **drawing.**

A. $F_2\underline{N}O^+$

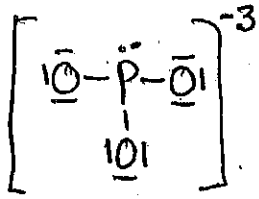


1) Electron-pair geometry about central N atom — Trigonal planar

2) Molecular geometry — Trigonal planar

3) Hybridization at central N atom — sp^2

B. $\underline{P}O_3^{3-}$

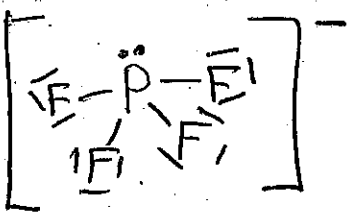
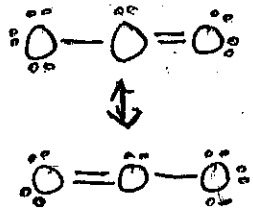
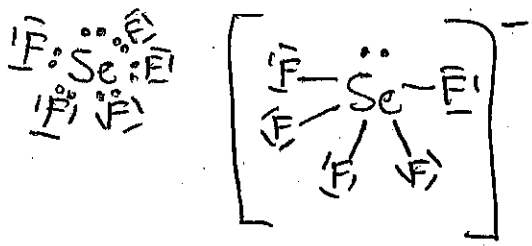


1) Electron-pair geometry about central P atom — Tetrahedral

2) Molecular geometry — Trigonal pyramid

3) Hybridization at central P atom — sp^3

2. (12 pts.) Draw an appropriate Lewis electron dot structure or resonance structures (**showing both the bonding and unshared electron pairs**) for each of the following species and identify the shape (geometry) of the molecule or ion. The underlined atom is the central atom to which each of the other atoms are linked. Describe the molecular geometry in **words** instead of only a **drawing.**

Species	**Lewis Structure (resonance structures)**	**Molecular Geometry**
A. ~~$\underline{NF_4}^-$~~ PF_4^-		see-saw
B. O_3 (Two O atoms attached to central O atom)		bent (or V-shaped, or nonlinear)
C. $\underline{SeF_5}^-$		square pyramid

PART IIC (9 pts.) For each of the following problems show your work with units.

1. (5 pts.) an automobile air bag is filled with nitrogen gas at room temperature (22°C) and a pressure of 850 torr by a gas-producing reaction involving the electric discharge of 200.0 g of solid sodium azide, $NaN_3(s)$, to completely generate sodium metal and $N_2(g)$ gas. Determine the resulting volume of gas produced in the air bag. Note that a balanced equation is needed.

295 K

$2\,NaN_3 \rightarrow 2\,Na(s) + 3\,N_2(g)$

don't include in moles of GAS

$200\,g\,NaN_3 \left(\frac{1\,mol\,NaN_3}{65.02\,g\,NaN_3}\right)\left(\frac{3\,mol\,N_2(g)}{2\,mol\,NaN_3}\right)$ (22.99, 3(14.01))

$\rightarrow 4.614\,mol\,N_2(g)$

$PV = n_{gas} R T$

$\left(\frac{850}{760}\,atm\right) V = (4.614\,mol)(.0821)(295)$

$V = 99.9\,L$

answer 99.9 L

2. (4 pts.) Calculate the temperature in °C for which the root-mean-speed of oxygen molecules is 650 m/s.

O_2

$\frac{1}{2} M u^2 = \frac{3}{2} R T$

$\left(\frac{.032\,kg}{mol}\right)\left(650\,\frac{m}{s}\right)^2 = 3(8.314)\,T$

$542\,K = T$

-273

$269°C$

answer 269°C