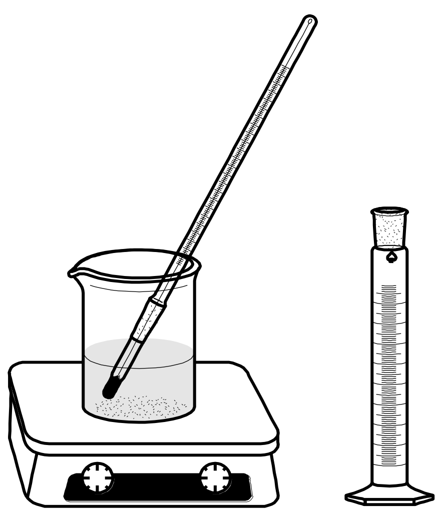
Houston Community College System

Chemistry 1411

EXAM # 3A Sample



CHEM 1411 EXAM # 3

(Chapters 8, 9,10,and 11)

Name:______________________________

Score:

Directions- please answer the following multiple-choice questions next to each number. Please show all your work for bonus question and part(2) questions in the space provided.

Part (1) - Multiple Choice - (3 points each)

_____ 1. How many unpaired electrons are in the Lewis dot symbol of a chlorine atom?

A. 7 B. 3 C. 5 D. 1 E. 8

_____ 2. Which of the following molecules consider to be a polar molecule?

A. NH_3 B. BF_3 C. CO_2 D. C_2H_2 E. CCl_4

_____ 3. Determine the total number of sigma and pi bonds in the following molecular structure.

```
H - C ≡  C -  C = C - C ≡  C- C ≡N:
              |     |
              H     H
```

A. 7 σ, 10 π B. 7 σ, 10 π C. 10 σ , 7 π D. 12 σ , 5 π E. none of these

_____ 4. Which one has the largest radius ?

A. K^+ B. K C. Al^{3+} D. Na^+ E. Mg

_____ 5. Which one is isoelectronic with Neon ?

A. F^- B. Al^{3+} C. Na^+ D. O^{2-} E. all of these

_____ 6. Which one violates octet rule stability ?

A. S^{2-} B. Mg^+ C. O^{2-} D. Fr^+ E. Al^{3+}

_____ 7. Which one of the following forms an ionic bond with Chlorine gas?

A. C B. Mg C. P D. As E. S

_____ 8. The configuration $(\sigma\ 2s)^2\ (\sigma\ 2s^*)^2\ (\pi\ 2p_x)^1(\pi\ 2p_y)^1$ is the molecular orbital description for the ground state of

A. Li_2^+ B. Be_2 C. B_2 D. B_2^{2-} E. C_2

_____ 9. Which of the following molecules is exception to octet rule.

A. PCl_5 B. $COCl_2$ C. BCl_3 D. CCl_4 E. two of these

_____ 10. Which of the following is the electron configuration for the Cr^{3+} ?

A. [Ar] $4s^2\ 3d^4$ B. [Ar] $4s^1\ 3d^5$ C. [Ar] $3d^3$ D. [Ar] $4s^2\ 3d^1$ E. none of these

_____11. As the bond order of a bond increases, the bond energy ________and the bond length __________.

A. increase, increase B. decrease, decrease C. increase, decrease
D. decrease, increase E. More information is needed to answer this question

____ 12. How many valence electron are in SO_4^{2-} ion?

A. $32e^-$ B. $30e^-$ C. $14e^-$ D $28e^-$ E. $24e^-$

_____ 13. Arrange the following atoms in order of increasing atomic radius: N, K, As, Fr

A. N < K < As < Fr B. N < As < K < Fr C. As < K < N < Fr
D. Fr < K < As < N E. K < Fr < N < As

_____ 14. What are the hybridization and the approximate bond angle CS_2 (C is the central atom) ?

A. sp^2, 107^0 B. sp^3, 120^0 C. sp^2, 120^0 D. sp, 180^0 E. sp, 120

_____ 15. The electron-pair geometry and molecular geometry of boron trichloride are respectively

A. tetrahedral,tetrahedral B. tetrahedral, trigonal planar C. trigonal planar, trigonal planar
D. tetrahedral, trigonal pyramidal E. tetrahedral, trigonal bipyramidal

_____ 16. Which of the following has bond order of 3 ?

I. N_2 II. CN^- III) O_2 IV) C_2^{2-}

A. I and II B. I only C. I,II, and IV D. II and III E. none of these

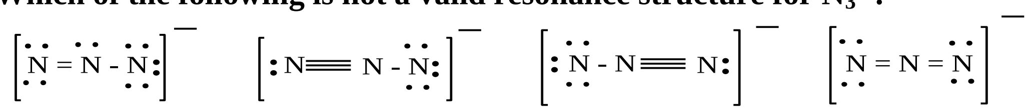
_____ 17. Which of the following groups contains no ionic compounds?

A. HCN, NO_2, $Ca(NO_3)_2$ B. PCl_5, LiBr, $Zn(OH)_2$ C. NaH, CCl_4, SF_4
D. KOH, CaF_2, $NaNH_2$ E. CH_2O, H_2S, NH_3

_____ 18. Which one of the following cubic cell contains only one atom?

A. Simple cubic cell B. Face centered cubic cell C. Body centered cubic cell
D. Edge Cubic cell E. none of these

_____ 19. Which of the following is not a valid resonance structure for N_3^- ?



I. II. III. IV.

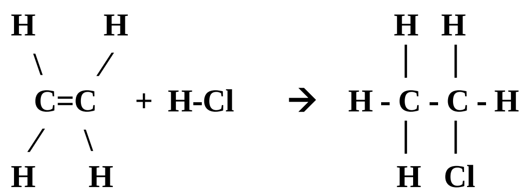
A. I only B. II only C. I and II D. II and IV E. all are correct

_____20. Which of the species below would you expect to show the least hydrogen bonding?

A. NH_3 B. H_2O C. HF D. CH_4 E. all the same

Part (2) - Show all your work. (8 points each)

21. Calculate the enthalpy change, ΔH , for the following gas-phase reaction using bond energy data.



Dissociation energy	
H-Cl	**435KJ/mol**
C-H	**413 KJ/mol**
C-C	**348 KJ/mol**
C=C	**614 KJ/mol**
C-Cl	**328 KJ/mol**

22. Draw Lewis dot (electron) structure for SO_3^{2-} and determine

a) electron geometry b) molecular geometry c) hybridization d) bond angle

23. Given N_2^{2-} , using molecular orbital and valence bond theory ;

a) Write molecular orbital configurations
b) Determine BOND ORDER and indicate stability
c) Identify the MAGNETIC properties (paramagnetic or diamagnetic)

24. Chromium metal crystallizes as body-centered lattice. If the atomic radius of Cr is 1.25 angstrums, what is the density of Cr metal in g /cm^3 ? (1 A^0 =1.0x10^{-8} cm , 1 g = 6.02x10^{23} a.m.u.)
(For bcc , $L = 4r /\sqrt{3}$)

25. Define the followings;
a) Triple point-

b) Sublimation-

c) Avogadro's law -

d) Bond order-

e) Critical temperature and Pressure--

BONUS question-Show all your work.(10 points)

You are given a small bar of an unknown metal , X. You find the density of the metal to be 10.5 g/cm^3.
An X-ray differaction experiment measures the edge of the unit cell as 409 pm. Assuming that the metal crystallizes in a face-centered lattice, what is metal , X, most likely to be?

CHEM 1411 EXAM # 3A (KEY)

1. D	6. B	11. C	16. C
2. A	7. B	12. A	17. E
3. C	8. C	13. B	18. A
4. B	9. E	14. D	19. A
5. E	10. C	15. C	20. D

21. ΔH = [614 + 435] - [328 + 348 + 413] = **-40 KJ**

22. SO_3^{2-} = $6e^-$ + 3 ($6e^-$) + $2e^-$ = $26e^-$ = 13 p.e^-

```
         ..
         S          2-
      /  |  \
   :O:  :O:  :O:
    ..   ..   ..
```

a) tetrahedral
b) triagonal pyramidal
c) sp^3
d) 107^o

23. N_2^{2-} = $16e^-$ = $(\sigma_{1s})^2 (\sigma_{1s}^*)^2 (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2py})^2 (\pi_{2pz})^2 (\sigma_{2px})^2 (\pi_{2py}^*)^1 (\pi_{2pz}^*)^1$ ➔ [:N = N :] $^{2-}$
.. ..

$$\text{B.O.} = \frac{10 - 6}{2} = 2$$; **paramagnetic**

24. Cr atome = 8(1/8) + 1(1) = 2 atoms
mass (g Cr) = (2)(51.996 amu)(1 g/ 6.022×10^{23} amu) = 1.73 $\times10^{-22}$ g
volume (cm^3) = L^3 = $(4 r / \sqrt{\mathbf{3}})^3$ = $(4\times1.25 \times 10^{-8}\ cm / \sqrt{\mathbf{3}})^3$ = $(4\times1.25 \times 10^{-8}\ cm / 1.73)^3$
= $2.41 \times10^{-23}\ cm^3$

D = (m /v) = (1.73×10^{-22} g / $2.41 \times10^{-23}\ cm^3$) = **7.18 g/cm^3**

25. a) **<u>Triple point</u>**: is the point where solid, liquid, and gas are all at equilibrium.
b) **<u>Sublimation :</u>** process by which solid changes to gas.
c) **<u>Avogadro's Law :</u>** 1 mole of any gas at S.T.P. condition has the volume of 22.4 liter (22400 ml).
d) **<u>Bond order :</u>** determines the number of bonds between two atoms.
e) **<u>Criptical points-</u>** The liquid –vapor line terminates at the critical point. At the critical temperature, a liquid has a vapor pressureequal to its critical pressure. Above the critical temperature a liquid phase cannot be formed.; the single phase that exists is called supercritical fluid.

<u>BONUS</u>

Number of X atoms = 8(1/8) + 6 (1/ 2) = 4 atoms of X

L= (409 pm) $\times10^{-12}$ m x 10^2 cm = 4.09 x10-8 cm ➔ V = L^3 = $(4.09 \times10^{-8}\ cm)^3$ = $6.84 \times10^{-23}\ cm^3$

m = d.v = (10.5 g /cm^3)($6.84 \times10^{-23}\ cm^3$) = 7.18×10^{-22} g

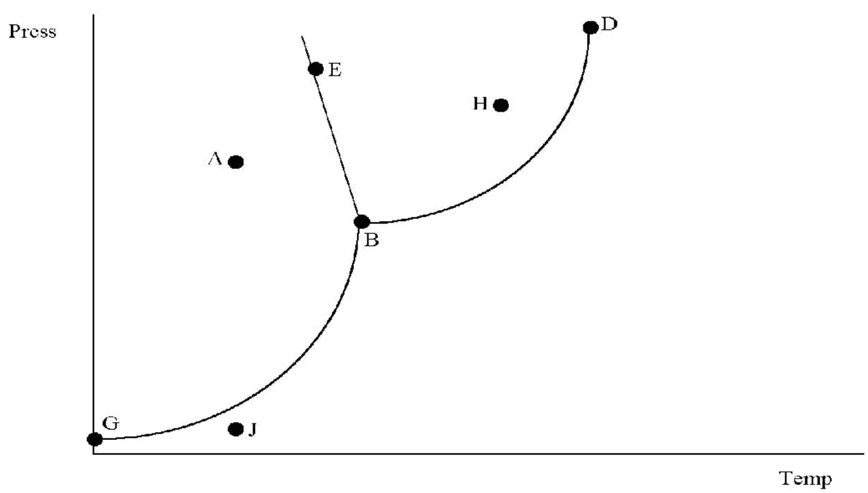
(7.18×10^{-22} g)(6.022×10^{23} amu/ 1 g) = 432 g amu

432 amu / 4 atoms of X = 108 amu / atom ➔ Silver atom , Ag

Houston Community College System

Chemistry 1411

EXAM # 3B Sample



CHEM 1411 EXAM # 3B **Name: ________________________**
(8,9,10, and 11)

Score:

Directions- please answer the following multiple-choice questions next to each number. Please show all your work for bonus question and part (2) questions in the space provided.

Part (1) - Multiple Choice - (3 points each)

_____ 1.Which molecule contains one unshared pair of valence electrons?
(A) H_2O (B) NH_3 (C) CH_4 (D) NaCl (E) CO_2

_____ 2. In the Lewis structure of SF_2, there are _____ single bonds and _____ total lone pairs?
(A) 2,8 (B) 3,8 (C) 2,2 (D) 2,6 (E) 3,6

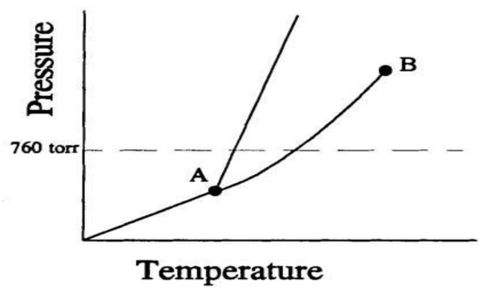
_____ 3. Which of the following molecules violates the octet rule?

(A) CBr_4 (B) NF_3 (C) OF_2 (D) PCl_3 (E) AsF_5

_____ 4. Which molecule exhibits resonance?

(A) O_3 (B) $BeCl_2$ (C) CO_2 (D) H_2Se (E) NF_3

____ 5. Examine the following phase diagram and identify the feature represented by point A.



(A) melting point (B)critical point (C) triple point (D) sublimation point

_____6. For which of the following molecules is the electron domain geometry **the same** as the molecular geometry of the molecule?
(A). O_3 (B). IF_5 (C) NH_3 (D) SO_4^{2-}

_____ 7. What are the formal charges on the boron and nitrogen in the compound BF_3-NH_3?
(A) -2 and +2 (B) +2 and –2 (C) 0 and 0
(D) +1 and –1 (E) -1 and +1

_____ 8. Which would be expected to be the most electronegative?
(A) P (B) As (C) Si (D) Al

_____ 9. According to modern bonding theory the number of sigma (σ) and pi (π) bonds in the ethylene molecule $H_2C = CH_2$ is
(A) 1 σ and 4 π (B) 1 π and 5 σ (C) 1 σ and 5 π (D) 2 π and 4 σ (E) 1 π and 4 σ

_____ 10. The element with the greatest tendency to gain electrons is

(A) F (B) At (C) O (D) N (E) Bi

_____ 11. What are the hybridization and angle of NF_3?

(A) $sp, 120^0$ (B) $sp^3, 109^0$ (C) $sp^2, 120^0$ (D) $sp^3, 107^0$

_____ 12. The strongest intermolecular interactions between ethyl alcohol (CH_3CH_2OH) molecules arise from

(A) dipole-dipole forces (B)London dispersion forces (C)hydrogen bonding (D) covalent bonding

_____ 13. Which of the following compounds contains the LEAST polar bonds?

Atoms	**H**	**S**	**P**	**As**	**Cl**	**Si**	**Sb**
Electronegativity	**2.1**	**2.5**	**2.1**	**2.1**	**3.0**	**1.8**	**1.9**

(A) PH_3 (B) $AsCl_3$ (C) SiH_4 (D) $SbCl_3$ (E) H_2S

_____ 14. Which pair is geometrically similar?
(A) SO_2 and CO_2 (B) CO_2 and OF_2 (C) PH_3 and BF_3 (D) SO_2 and O_3

_____ 15. A molecule consists of four bonding pairs of electrons and no lone pairs. What is its structure?
(A) square planar (B) tetrahedral (C) linear (D) square pyramidal

_____ 16. Which of the following species is paramagnetic?
(A) O_2 only (B) N_2 only (C) N_2 and B_2 (D) N_2 and O_2 (E) B_2 and O_2

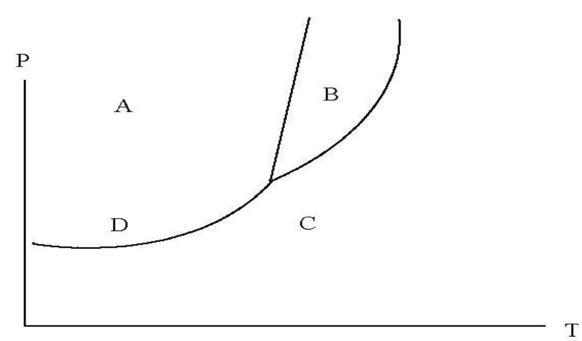
_____ 17. Predict the real bond angles in $SeCl_2$ using the VSEPR theory:
(A) more than 120° (B) between 109 and 120 (C) between 90 and 109 (D) 90

_____ 18. The lattice energy for ionic crystals increases as the charge on the ions ___ and the size of the ions ___?

(A) increases, increases (B) increases, decreases
(C) decreases, increases (D) decreases, decreases

_____ 19. Molecular Orbital Theory describes the bond order in He^{2+} as:
(A) 0 (B) 0.5 (C) 1 (D) 1.5 (E) 2

_____ 20. What are the changes in phase going from points A → B → C → D



A. melting, vaporization, deposition B. vaporization, freezing, sublimation
C. submination, freezing, melting D. freezing, sublimation, vaporization
E. melting, sublimation, deposition

Part (2) - Show all your work. (8 points each)

21. For $\mathbf{CO_3}^{\mathbf{2-}}$, sulfate ion, draw the **Lewis structure** (by counting valence electrons of each atom), determine the **electron-domain geometry**, molecular **geometry**, hybridization**,** and show the **angle** between the bonds in a drawing. S is the central atom, all other atoms are attached to C.

22. Given $C_2^{\ 2-}$, using molecular orbital and valence bond theory;
    a) Write **molecular orbital** configuration
    b) Determine **BOND ORDER** and indicate stability
    c) Identify the **MAGNETIC** properties (paramagnetic or diamagnetic)

23. Calculate the enthalpy change, **ΔH**, for the following reaction using bond dissociation energy data. Bond dissociation energies, given in kJ/mole:

$$\mathbf{NH_{3(g)} + Cl_{2(g)} \rightarrow NH_2Cl_{(g)} + HCl_{(g)}}$$

N—H = 389 Cl—Cl = 243 H—Cl = 431 N—Cl = 201

24. A metal crystallizes with a face-centered cubic lattice. The edge of the unit cell is 408 pm. Calculate the **number of atoms** in the unit cell and **diameter** of the metal atom. (For FCC , edge = r $\sqrt{8}$)

25. Consider the following molecules, $\mathbf{H_2}$, $\mathbf{CN^-}$, $\mathbf{He_2}$, and $\mathbf{O_2}$.

    a) Which one has a bond order of 2? ____________

    b) Which one is unstable molecule? ____________

    c) Which one has a single bond? ____________

    d) Write them in order of increasing stability.

Bonus question (10 points). Please Show all your work for complete credit.

When silver crystallizes, it forms face-centered cubic cells. The unit cell edge is 408.7 pm. Given the density of silver is 10.5 g/cm^3, calculate the **Avogadro's number**.

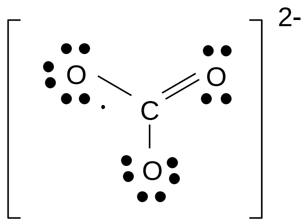
CHEM 1411 EXAM # 3B (KEY)

PART - I

1. B	4. A	7. E	10. A	13. A	16. E	19. A
2. A	5. C	8. A	11. D	14. D	17. C	20. A
3. E	6. D	9. B	12. C	15. B	18. B	

PART - II

21. CO_3^{-2} = $4e^- + 3(6e^-) + 2e^-$ = $24\ e^-$ = 12 pairs of electrons



three resonances

electron domain geometry: trigonal planar **molecular geometry:** trigonal planar
bond angle: 120^o **hybridization:** sp^2

22. $C_2^{2-} = 2(6e^-) + 2e^- = 14\ e^-$

a) $(\sigma_{1s})^2 (\sigma_{1s}^*)^2 (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2}p_y)^2 (\pi_{2}p_z)^2 (\sigma_{2}p_x)^2$
b) bond – order = (10 –4)/2 = 3 triple bond ➔ $[:C \equiv C:]^{2-}$
c) diamagnetic

23. ΔH = [D (N-H) + D(Cl- Cl))] – [D (N - Cl) + D (H – Cl)] =
[(389 + 243) – (201 + 431) = (632) – 9632) = **<u>0 kJ</u>**

24. number of atoms = 8(1/8) = 6(1/2) = **4 atoms**

edge= a = r $\sqrt{8}$ ➔ r = a / $\sqrt{8}$ ➔ diam. = 2 r = 2 (408pm/ 2.83) = **288.5 pm** ➔ **2.88×10^{-10} m**

25. a) O_2 b) He_2 c) H_2 d) $He_2 > H_2 > O_2 > CN^-$

<u>Bonus Question</u>

Number of atoms Ag = (8x1/8) + (6x1/2) = 4 Ag atoms

V = $(408.7\ \text{pm} \times 10^{-12}\ \text{m} \times 10^{2}\ \text{cm})^3 = 6.827 \times 10^{-23}\ \text{cm}^3$

Mass = m = D.V = $(10.5\ \text{g/cm}^3)(6.827 \times 10^{-23}\ \text{cm}^3) = 7.168 \times 10^{-22}$ g

(4 Ag atoms)(107.868 amu/ 1 Ag atom) (1.0 g / AV # amu) = 7.168×10^{-22} g

AV # = (4 Ag atoms)(107.868 amu/ 1 Ag atom) (1.0 g / 7.168×10^{-22} g) = **6.019×10^{23} amu/g**

OR:
AV # = (number of atoms x atomic weight)/ mass = (4x107.868 amu)/ D.V
= (4x107.868 amu) / (7.168×10^{-22} g) = **6.019×10^{23} amu/g**