CHEM 14A
Instructor: Dr. Laurence Lavelle

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FALL 2007
MIDTERM

(Total number of pages = 10)

(Total points = 110)

(Total time = 110 minutes)

__Carefully__ remove the last two pages: Constants and Formulas, and Periodic Table.

YOUR DISCUSSION SECTION Fri 10-11

YOUR TA's NAME Sid Kannan

WRITE IN PEN (Show all your work on this paper, check units and significant figures.)

Good Luck

Do not write on this page.

QUESTION	SCORE
1	6
2	14
3	
4	
5	
6	
TOTAL (max 110)	

1 (Honors)	
2 (Honors)	
TOTAL (max 50)	

Q1. A 1.000 g sample of XI_2 is dissolved in water, and excess silver nitrate ($AgNO_3$) is added to precipitate all of the iodide as AgI. The mass of the dry AgI is found to be 1.597 g. What is the identity of X^{2+} ? (12 pt)

6

1g XI_2 $XI_2 + H_2O \rightarrow AgNO_3 \rightarrow AgI + H_2O_2$

$1.597\text{g AgI} \times \frac{1\text{mol AgI}}{234.77\text{g AgI}} \times \frac{1\text{mol I}}{1\text{mol AgI}} \times \frac{126.9\text{g I}}{1\text{mol I}_2} = .8632\text{g I}$

4

24

$XI_2 + H_2O_{(l)} + AgNO_{3(s)} \rightarrow AgI_{(s)} + N_2 + O_2 + H_2$

ionic equation: $X^{2+} + I^+ + H^- + O^{2+} + AgNO_3 \rightarrow AgI_{(s)} + \text{[illegible]} + O^{2+} + H^- + I^+ + X^{2-}$

$\%I = \frac{.8632\text{g I}}{1.597\text{g AgI}} = 54.05\%\text{ I}$ $\rightarrow XI_2 + AgNO_3 \rightarrow AgI + NO_2$

1g XI_2

need mass of Ag: 107.868g

mass $AgNO_3$ = 169.868g

$XI_2 \Rightarrow gX + .8632\text{g I} \rightarrow 1 - .8632 = .1368\text{g X}$

$\%X = 13.68\%$

12.6R

2

.1368g X ——— $\frac{.8632\text{g I}}{.1368\text{g X}} = 6.3099$ ratio

$\rightarrow 126.9\text{g I} \div 6.3099 = 20.1\text{g}$ → Ne

$1.597\text{g AgI} \times \frac{1\text{mol AgI}}{234.77\text{g AgI}} \times \frac{1\text{mol I}}{1\text{mol AgI}} \times \frac{126.9\text{g I}}{1\text{mol I}} = .8632\text{g I}$

X^{2+} Ne Cl

Q2. If the wavelength of incident light on sodium metal was 810 nm, and the work function of sodium is 1.1 eV, what is the wavelength of the ejected electron? (16pt)

14

$\lambda = 810\,nm \times \frac{10^{-9}\,m}{1\,nm} = 8.1 \times 10^{-7}\,m$ ✓ (2)

$\phi = 1.1\,eV \times \frac{1.602 \times 10^{-19}\,J}{1\,eV} = 1.7622 \times 10^{-19}\,J$ ✓ (2)

$E_{incoming} = \phi - KE$, λ ejected e^-

$E = \frac{hc}{\lambda} \rightarrow E = \frac{(6.62608 \times 10^{-34}\,J \cdot s)(3 \times 10^{8}\,m/s)}{(8.1 \times 10^{-7}\,m)} = 2.4541037 \times 10^{-19}\,J$ ✓ (2)

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.1 \times 10^{-31}\,kg)v^2$

$KE = E_{incoming} - \phi$

$\frac{1}{2}(9.1 \times 10^{-31}\,kg)v^2 = 2.4541037 \times 10^{-19}\,J - 1.7622 \times 10^{-19}\,J$

$= 6.919037 \times 10^{-20}\,J$

$\rightarrow v^2 = 1.520667473 \times 10^{-17}$ $\rightarrow v = 4 \times 10^{-9}$ (2)

$\lambda = \frac{h}{mv} \rightarrow \lambda = \frac{(6.62608 \times 10^{-34}\,J \cdot s)}{(9.1 \times 10^{-31}\,kg)(\sqrt{1.520667473 \times 10^{-17}})}$ (4)

$\lambda = \frac{(1.000728141)}{(\sqrt{1.520667473 \times 10^{-17}})} = 1.86723 \times 10^{-23}\,m$

$= \boxed{1.87 \times 10^{-23}\,m}$ (2)

Q3A. The average speed of a helium atom at 25°C is 1.23×10^3 m · s^{-1}.
What is the average wavelength of a helium atom at this temperature? (9pt)

Velocity = $v = 1.23 \times 10^3$ m/s

$\lambda = ?$ $\quad \lambda = \frac{h}{p} \Rightarrow \lambda = \frac{h}{mv}$

m He atom $= \frac{4.003\ g/mol}{6.0221 \times 10^{23}\ mol^{-1}} = 6.647138725 \times 10^{-24}\ g$

$\lambda = \frac{(6.62608 \times 10^{-34}\ J \cdot s)}{(6.647138725 \times 10^{-24}\ g)(1.23 \times 10^3\ m/s)} = \boxed{8.10 \times 10^{-14}\ m}$

Q3B. What is the maximum number of electrons in an atom that can have these quantum numbers? (9pt)

a) $n = 4, l = 2$ Ans 10 e^-

b) $n = 3$ Ans 8 e^-

c) $n = 5, m_s = +1/2$ Ans 25 e^-

a) 4d 18 spdf
l 0123

b) 3 — — — 13/18

c) 5s + 5p

Q4A. What is the ground-state electron configuration expected for each of the following elements? (6pt)

(a) sulfur Ans [Ne]$3s^2 3p^4$

[Ne]$3s^2 3p^4$

(b) cesium Ans [Xe]$6s^1$

(c) vanadium Ans [Ar]$3d^3 4s^2$

[Ar]$4s^2 3d^3$

Q4B. Which M^{2+} ions (where M is a metal) are predicted to have the following ground-state electron configurations (a) [Ar]$3d^7$; (b) [Kr]$4d^{10}5s^2$? (6pt)

(a) Ans [redacted] Co^{2+}

(b) Ans [redacted] Sn^{2+}

[Ar]$3d^7$ $+2e^-$ → [Ar]$3d^7$ $4s^2$ → Co

[Kr]$4d^{10}5s^2$ $+2e^-$ → ~~[Kr]$4d^{10}5s^2$ → Ge~~ Sn

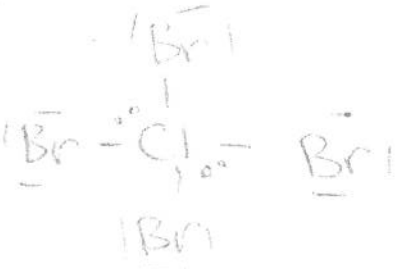
Q5. Predict the shape and state if the compound is polar or non-polar.

Only your two word answer will be graded. (4pt each = 20pt)

$ClBr_4^-$ Ans nonpolar, square planar

ves: $7+4(7)=35$

$7+4(7)+1=36$



BrF_5 Ans polar, square pyramidal

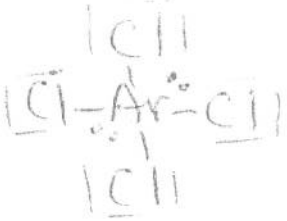
ves: $5(7)+7=42$

AX_5E

Square pyramidal

$ArCl_4$ Ans nonpolar, square planar

ves: $8+4(7)=36$

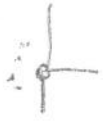


H_2S Ans polar, bent

ves: $2+6=8$

ClF_3 Ans polar, T-shaped

ves: $7+3(7)=28$

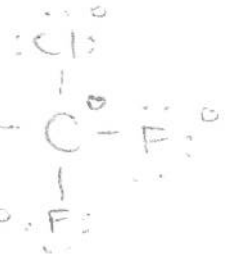


AX_3E_2

Q6. Write the Lewis structure and the VSEPR formula, list the shape, and predict the approximate bond angles for the following.

(a) CF_3Cl (8pt)

VES: $4 + 3(7) + 7 = 4 + 21 + 7 = 32$ ves



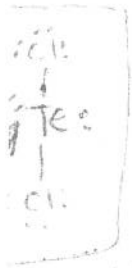
AX4

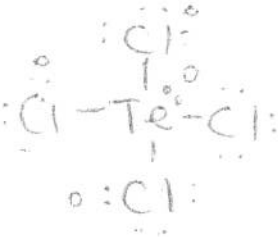
tetrahedral

bond angles: 109.5°

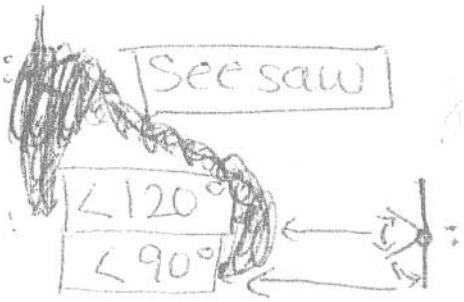
(b) $TeCl_4$ (8pt)

ves: $6 + 4(7) = 6 + 28 = 34$ ves





AX4E

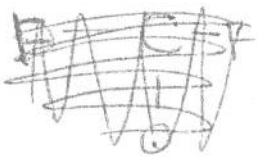


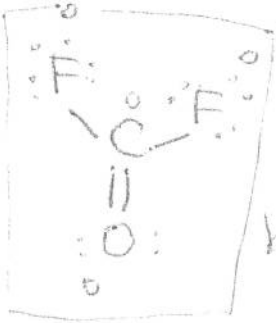
See saw

bond angles: <120°, <90°

(c) COF_2 (8pt)

ves: $4 + 6 + 2(7) = 24$ ves





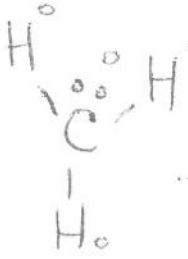
AX3

trigonal planar

bond angle: 120°

(d) CH_3^- (8pt)

ves: $4 + 3(1) + 1 = 8$ ves



AX3E

trigonal pyramidal

bond angle: <109.5°