

# Chemistry 1035 – Exam #4

April 29, 2004

Name: \_\_\_\_\_ KEY \_\_\_\_\_

Student Number: \_\_\_\_\_

## The Virginia Tech Honor Code

The Honor Code will be strictly enforced in this course. All assignments submitted shall be considered graded work, unless otherwise noted. All aspects of your coursework are covered by the Honor System. Any suspected violations of the Honor Code will be promptly reported to the Honor System. Honesty in your academic work will develop into professional integrity. The faculty and students of Virginia Tech will not tolerate any form of academic dishonesty.

Honor Code Pledge: \_\_\_\_\_  
(signature)

Calculator Policy – The use of scientific calculators is permitted for calculating the answers to numerical problems on this examination. Cellular telephones may not be used as calculators during this examination. Likewise, PDA's (e.g. Palm devices) may not be used as calculators during this examination.

Equations:

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$E = hv$$

$$q = c \cdot m \cdot \Delta T$$

$$v\lambda = c$$

Constants:

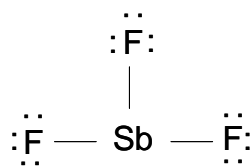
$$R = 8.3145 \text{ J/K}\cdot\text{mole}$$

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{sec}$$

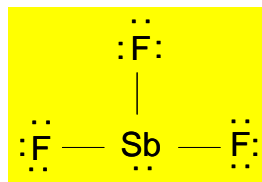
$$c = 3.00 \times 10^8 \text{ m/sec}$$

1. Which of the following is the correct Lewis dot structure for  $\text{SbF}_3$ ?

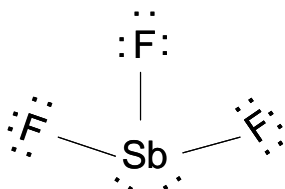
a.



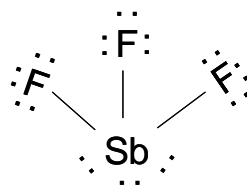
b.



c.



d.



2. Which of the following molecules/ions do not have multiple resonance forms?

a.  $\text{O}_3$

b.  $\text{SO}_3$

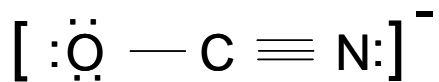
c.  $\text{SO}_2$

d.  $\text{SO}_3^{2-}$

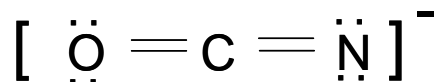
Generate the Lewis structures for each of these. The  $\text{SO}_3^-$  is the only one in which the central atom can have an octet without the need to form double bonds with the surrounding atoms. Hence it does not have multiple resonance forms

3. For the molecular ion  $\text{OCN}^-$  which resonance form is the least stable?

a.



b.

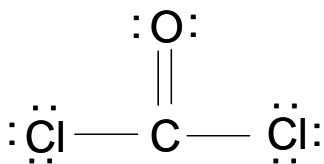


c.



Calculate the formal charges on the atoms in these resonance forms. You will find that in answer (c) the formal charge on the oxygen atom (the most electronegative atom in this molecular ion) is +1, and the formal charge on the Nitrogen is -2. Unfavored resonance structures try to place a positive formal charge on electronegative atoms, and require large charge values on other atoms. The other 2 resonance forms only have -1 charges on the oxygen (a) or on the nitrogen (b) and no charge on the other ions.

4. What is the oxidation number for the O atom in the following Lewis dot structure?



a. -2

b. -1

c. 0

d. 1

e. 2

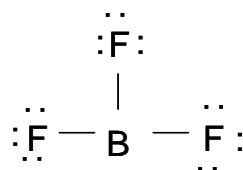
The oxidation number is calculated by:

(# electrons on unbonded atom) - (#electrons in lone pairs) - (#electrons in covalent bonds)

Importantly, the bonding electrons all go with the more electronegative atom in the bonding pair. For the oxygen therefore,  $\text{O.N.} = 6 - 4 - 4 = -2$

5. Which exception to the octet rule does  $\text{BF}_3$  demonstrate?

- a. Electron deficient
- b. Odd-electron
- c. Expanded Valence Shell (Octet)
- d. Multiple bond resonance



After determining the Lewis structure, you find that there are not enough electrons to satisfy the octet for B. Because F is so electronegative, the B is electron deficient

6. Which of the following atoms can *not* expand its octet?

- a. Kr
- b. Se
- c. Cl
- d. O

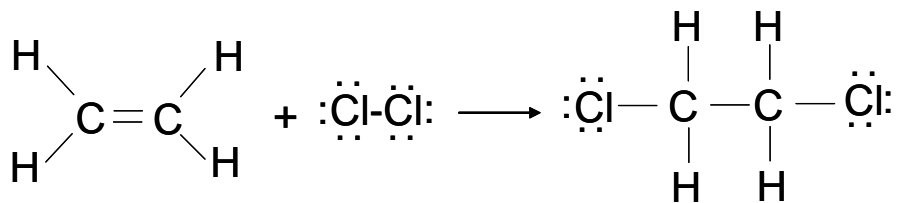
Oxygen does not have any d orbitals in its valence shell and, therefore, cannot expand its octet

7. What is the VSEPR base structure for  $\text{SeF}_4$ ?

- a. Linear
- b. trigonal planar
- c. tetrahedral
- d. trigonal bipyramidal
- e. octahedral

Determine the Lewis structure and find that  $\text{SeF}_4$  has 5 groups surrounding the Se atom (one lone pair)

8. Given the following bond energy data, what is the heat of reaction ( $\Delta H_{\text{rxn}}$ ) for:



Bond Energy:

C-H	413 kJ/mole
C=C	614 kJ/mole
Cl-Cl	243 kJ/mole
C-C	347 kJ/mole
C-Cl	339 kJ/mole

- a. +270 kJ
- b. +168 kJ
- c. -168 kJ
- d. -270 kJ

$$\Delta H_{\text{rxn}} = \{614 + 4(413) + 243\} - \{347 + 4(413) + 2(339)\}$$

$$\Delta H_{\text{rxn}} = 2509 - 2677 = -168 \text{ kJ}$$

9. Of the following, which is the most likely bond angle for the ion  $\text{ClO}_3^-$ ?

- a.  $107.5^\circ$
- b.  $109.5^\circ$
- c.  $110.5^\circ$
- d.  $118^\circ$
- e.  $120^\circ$
- f.  $122^\circ$

$\text{ClO}_3^-$  is found to have a tetrahedral base structure (4 groups attached to the Cl from the Lewis structure). Because one of these groups is a lone pair, the bond angle is less than the ideal tetrahedral bond angle

10. Which of the following molecules will have the largest dipole moment?

- a.  $\text{XeF}_2$
- b.  $\text{BF}_3$
- c.  $\text{PF}_3$
- d.  $\text{CF}_4$

All of these are found to be symmetric VSEPR structures except  $\text{PF}_3$ , which is trigonal pyramidal. Consequently, it is the only one that has a dipole moment

11. What is the hybridization of the C atom in CO<sub>2</sub>?

- a. sp
- b. sp<sup>2</sup>
- c. sp<sup>3</sup>
- d. dsp<sup>3</sup>
- e. d<sup>2</sup>sp<sup>3</sup>

CO<sub>2</sub> is found to have a linear VSEPR structure which corresponds to sp hybridization

12. How many hybrid orbitals are formed when one “s” orbital combines with two “p” orbitals to form the sp<sup>2</sup> hybrid orbital?

- a. 0
- b. 1
- c. 2
- d. 3
- e. 4

There are 3 sp<sup>2</sup> hybrid orbitals

13. For which type of bond does the electron density lie predominantly along the axis connecting the two bonding atoms?

- a. Ionic
- b. Metallic
- c. Sigma      Sigma bonds result from end-to-end overlap of atomic orbitals putting the electrons along the axis connecting the atoms
- d. Pi

14. True or False, a π-bond restricts the rotation about the σ-bond axis?

- a. True
- b. False

15. Hybrid orbitals are formed by mixing the atomic orbitals within a single atom. Are the hybrid orbitals formed by this mixing degenerate in energy?

- a. Yes
- b. No

16. Molecular oxygen,  $O_2$ , is paramagnetic. Which of the following representations of the molecule's valence electrons correctly predicts this behavior?
- Lewis Dot structure
  - VSEPR structure
  - Molecular Orbital structure
  - Atomic Electron configuration

17. What is the bond order for the molecule  $Be_2$ ?

- 0
- 1
- 2
- 3

After determining the molecular orbital diagram for  $Be$  ( $1s^2 2s^2$ ) you find that both the  $\sigma_{2s}$  and the  $\sigma_{2s}^*$  orbitals have 2 electrons each. The Bond order is given by:

$$B. O. = \frac{1}{2} \{ (\# \text{ of electrons in bonding orbitals}) - (\# \text{ of electrons in antibonding orbitals}) \}$$

18. Of the following, which is the weakest intermolecular interaction?
- Ion-dipole
  - Dipole-dipole
  - Hydrogen bonding
  - Dipole-Induced dipole
  - Dispersion

19. How much heat is required to raise the temperature of 18.0gms of ice at  $-25^{\circ}\text{C}$  to 18.0gms of a liquid at  $10^{\circ}\text{C}$ ?

$$c_{\text{ice}} = 2.09 \text{ J/g}\cdot\text{K}$$

$$c_{\text{water}} = 4.184 \text{ J/g}\cdot\text{K}$$

$$\Delta H_{\text{fusion}} = 5.98 \text{ kJ/mole}$$

$$\Delta H_{\text{vap}} = 40.7 \text{ kJ/mole}$$

- a. 1.70 kJ  
**b. 7.67 kJ**  
 c. 4.29 kJ  
 d. 109.1 kJ

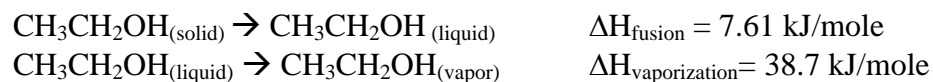
$$q_{\text{tot}} = c_{\text{ice}}m\Delta T + \Delta H_{\text{fusion}}(\text{moles}) + c_{\text{water}}m\Delta T$$

$$q_{\text{tot}} = (2.09 \text{ J/g}\cdot\text{K})(18 \text{ gm})(0 - (-25)) + \left(\frac{5.98 \text{ kJ}}{\text{mole}} \times \frac{1000 \text{ J}}{\text{kJ}} \times 1 \text{ mole } H_2O\right) + (4.184 \text{ J/g}\cdot\text{K})(18 \text{ gm})(10 - 0)$$

$$q_{\text{tot}} = 940.5 \text{ J} + 5980 \text{ J} + 753 \text{ J}$$

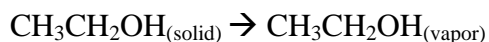
$$q_{\text{tot}} = 7674 \text{ J} = 7.674 \text{ kJ}$$

20. What is the heat of sublimation for  $\text{CH}_3\text{CH}_2\text{OH}$  if:



- a. -46.31 kJ/mole  
 b. -31.09 kJ/mole  
 c. 7.61 kJ/mole  
 d. 31.09 kJ/mole  
**e. 46.31 kJ/mole**

Apply Hess's law of heat summation to determine that:



Is simply the sum of the fusion reaction and the vaporization reaction. The heat of sublimation, therefore, is just the sum of the heats of fusion and the heats of vaporization (7.61+38.7)

21. What is the definition of the triple point of a compound?
- The pressure-temperature combination in a phase diagram where the solid, liquid, and vapor phases of a material are all in equilibrium.
  - The pressure-temperature combination in a phase diagram beyond which a 4<sup>th</sup> phase of matter, known as a supercritical fluid, is formed.
  - The temperature in a phase diagram beyond which the vapor pressure of a compound always exceeds 3 atmospheres
  - The pressure in a phase diagram below which the compound is in the solid phase regardless of the temperature.
22. If  $\Delta H_{\text{vap}} = 40.5 \text{ kJ/mole}$  for ethanol, and the boiling temperature is  $77^\circ \text{ C}$ . What is the vapor pressure at  $35^\circ \text{ C}$ ?
- 1.90 atmospheres
  - 0.0180 atmospheres
  - 0.150 atmospheres
  - 0.670 atmospheres

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{P_2}{1\text{atmosphere}}\right) = \frac{-40.5\text{kJ}}{\text{mole}} \times \frac{1000\text{J}}{\text{kJ}} \left(\frac{1}{35 + 273.15} - \frac{1}{77 + 273.15}\right)$$

$$\ln\left(\frac{P_2}{1\text{atmosphere}}\right) = -1.896$$

$$P_2 = 0.150\text{atmosphere}$$

23. Of the following, which will have the higher boiling temperature?
- a. **CH<sub>3</sub>OH**      Methanol will have stronger intermolecular interactions
  - b. CH<sub>3</sub>CH<sub>3</sub>
  - c. H<sub>2</sub>C=O
24. Of the following atoms, which is the most polarizable?
- a. F
  - b. Br
  - c. C
  - d. **Ge**      Ge is the largest of these atoms
25. What is the definition of viscosity?
- a. The energy required to increase the area of a liquid by a unit amount
  - b. **The resistance of a liquid to flowing**
  - c. The rising of a liquid through a small gap against the force of gravity
  - d. The mass per unit volume of the liquid phase of a compound