Chemistry 1A, Spring 2003

Midterm 2, KUBINEC
March 10, 2003
(90 min, closed book)

Name:___________________

SID:_____________________

TA Name:________________ section number

- This exam has 45 multiple choice questions.
- Fill in the Scantron form AND circle your answer on the exam.
- Each question is worth 3.33 points.

Note:

- THE QUESTIONS ON THIS EXAM MAY BE ANSWERED IN ANY ORDER.
- QUESTIONS THAT CONTAIN '(MARK ALL THAT APPLY)' MAY REQUIRE MORE THAN ONE ANSWER TO BE BUBBLED IN TO RECIEVE CREDIT.

Potentially useful relations:

$E = h\nu$

$\lambda\nu = c$

$\lambda_{deBroglie} = h / p = h / mv$

E_{kin} (e-) $= h\nu - \Phi = h\nu - h\nu_0$

$$E_n = -\frac{Z^2}{n^2} R_\infty$$

$PV = nRT$

$$E_{kin} = \frac{3}{2} RT$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$\Delta E = q + w$

$w = - P_{ext}\Delta V$

$$\Delta E = \frac{3}{2} nR\Delta T$$

$N_0 = 6.02214 \times 10^{23}$ mol^{-1}

$R_\infty = 2.179874 \times 10^{-18}$ J

$R_\infty = 3.28984 \times 10^{15}$ Hz

$k = 1.38066 \times 10^{-23}$ J K^{-1}

$h = 6.62608 \times 10^{-34}$ J s

$m_e = 9.101939 \times 10^{-31}$ kg

$c = 2.99792 \times 10^{8}$ m s^{-1}

Gas Constant:

$R = 8.31451$ J K^{-1} mol^{-1}

$R = 8.20578 \times 10^{-2}$ L atm K^{-1} mol^{-1}

T (K) = T (C) + 273.15

F = 96,485 C / mol

1 V = 1 J / C 1 nm = 10^{-9} m

1 kJ = 1000 J

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma\, \Delta H°_f$ (products) $- \Sigma\, \Delta H°_f$ (reactants)

$\Delta S° = \Sigma\, S°$ (products) $- \Sigma\, S°$ (reactants)

$\Delta G° = \Sigma\, \Delta G°_f$ (products) $- \Sigma\, \Delta G°_f$ (reactants)

$S = k_B \ln W$

for $aA + bB \rightleftarrows cC + dD$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ At equilibrium, Q = K

$\Delta G° = - RT\ln K$

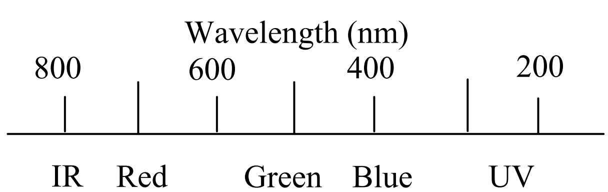
$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta \mathcal{E}°$

$pX = - \log X$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

Color and Wavelength of Light



ΔG° of Formation

compound	ΔG° (kJ / mol)
CO_2	-394.36
H_2O (g)	-228.57
$C_6H_{12}O_6$	-910
O_2	0

SECTION 1: PERIODIC PROPERTIES

1.) Which is the proper ordering of the following elements from lowest ionization energy to highest?

A) Na, Mg, Si, S, Ar
B) Ar, Na, Si, S, Mg
C) Ar, S, Si, Mg, Na
D) Mg, Na, Si, Ar, S
E) Si, S, Ar, Na, Mg

2.) Which is the proper ordering of the following elements from smallest atomic radius to largest?

A) Na, Mg, Si, S, Ar
B) Ar, Na, Si, S, Mg
C) Ar, S, Si, Mg, Na
D) Mg, Na, Si, Ar, S
E) Si, S, Ar, Na, Mg

3.) Which species has the highest ionization energy?

A) Br^{1-} B) Kr C) Sr^{2+} D) Rb^{+} E) Se^{2-}

4.) From which orbital must an electron be removed from the Sr^{2+} ion in its ground state to form Sr^{3+}?

A) 5s B) 4s C) 5p D) 4p E) 3d

SECTION 2: MOLECULAR STRUCTURE AND BONDING

The following eight questions refer to the complete Lewis structure for the cyanide ion (CN^{1-}).

5.) What is the formal charge on the carbon?

A) -3 B) -1 C) 0 D) 1 E) 2

6.) What is the formal charge on the nitrogen?

A) -3 B) -1 C) 0 D) 1 E) 2

7.) What is the oxidation number on the carbon?

A) -3 B) -1 C) 0 D) 1 E) 2

8.) What is the oxidation number on the nitrogen?

A) -3 B) -1 C) 0 D) 1 E) 2

9.) What is the bond order of the C-N bond?

A) 1 B) 2 C) 3 D) 4 E) can't tell

10.) What is the hybridization of the N?

A) s B) p C) sp D) sp^2 E) sp^3

11.) What is the hybridization of the C?

A) s B) p C) sp D) sp^2 E) sp^3

12.) What is the best description of the sigma bond in CN^{1-}?

A) 2p on carbon combined with 2p on nitrogen.
B) 2s on carbon combined with 2s on nitrogen.
C) sp^3 on carbon combined with sp^3 on nitrogen.
D) sp^2 on carbon combined with sp^2 on nitrogen.
E) sp on carbon combined with sp on nitrogen.

Continue with the next question:

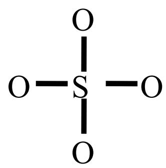
13.) In hydrogen cyanide the configuration is H-C-N. What is the best description of the CH bond?

A) 2p on carbon combined with 2p on hydrogen.
B) 2s on carbon combined with 1s on hydrogen.
C) sp^3 on carbon combined with 1s on hydrogen
D) sp^2 on carbon combined with sp^2 on hydrogen
E) sp on carbon combined with 1s on hydrogen

14.) What is the formal charge on carbon in HCN?

A) -3 B) -1 C) 0 D) 1 E) 2

Complete the Lewis structure for the sulfate ion (SO_4^{2-}) and answer the following three questions. Note that oxygen is more electronegative than sulfur.



15.) What is the oxidation number of the sulfur?

A) -6 B) -2 C) 0 D) 2 E) 6

16.) What is the shape of the sulfate ion?

A) Linear.
B) Bent.
C) Trigonal pyramidal.
D) Square planar.
E) Tetrahedral.

17.) What is the bond order of the SO bonds in SO_4^{2-}?

A) 0 B) 0.5 C) 1 D) 1.5 E) 2

Continue with the next question:

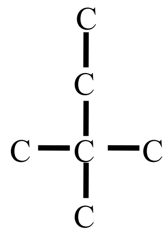
18.) Which molecular shape has the largest bond angle?

A) Tetrahedral
B) Square planar
C) Trigonal pyramid
D) Trigonal planar
E) Octahedral.

19.) Which molecular shape has a dipole moment if all the terminal atoms are identical?

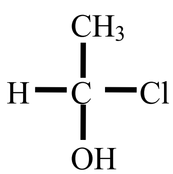
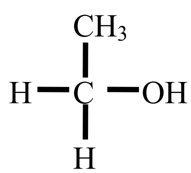
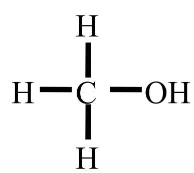
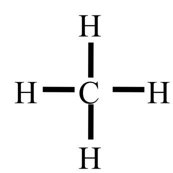
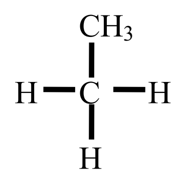
A) Tetrahedral
B) Square planar
C) Trigonal pyramid
D) Trigonal planar
E) Octahedral.

20.) How many structural isomers (do not count stereo isomers) can be formed by replacing a hydrogen atom with a chlorine atom on the following molecule (C_6H_{14}) without changing any C-C bonds (hydrogen atoms are not shown)?



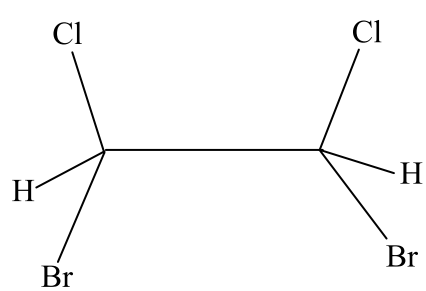
A) 1 B) 3 C) 6 D) 8 E) 10

21.) Which of the following is chiral?

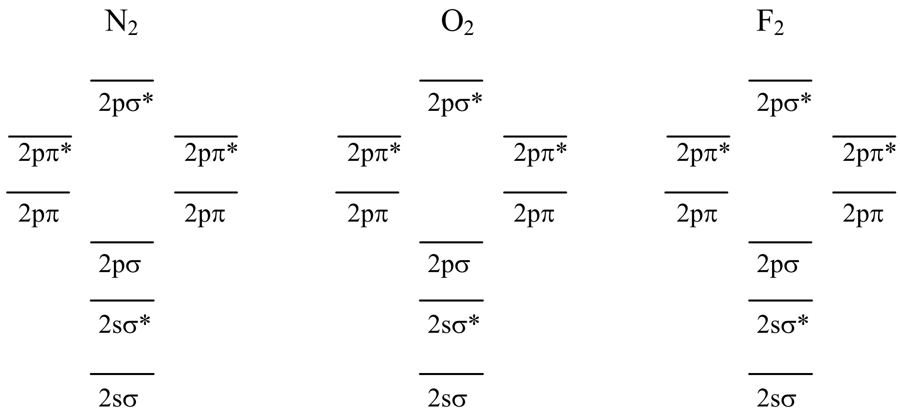
A)  B)  C)  D)  E) 

22.) Some molecules have more than one chiral carbon. In this case, the molecule itself may or may not be chiral. Which is true about the following molecule?

A) It is chiral because it has a chiral carbon.
B) It is chiral because it has two chiral carbons.
C) It is achiral (not chiral) because it is the same as its mirror image.
D) It is chiral because it is different from its mirror image.
E) It is achiral (not chiral) because it has no chiral carbons.



Consider the molecules and molecular ions F_2 and F_2^{1-}, O_2 and O_2^{1-}, and N_2 and N_2^{1-} to answer the following four questions (the relative energies of the molecular orbitals for each is shown).



23.) Which of the following, according to molecular orbital theory, has the strongest bond?

A) F_2 B) F_2^{1-} C) O_2^{1-} D) O_2 E) N_2^{1-}

24.) Which of the following, according to molecular orbital theory, has the weakest bond?

A) F_2 B) F_2^{1-} C) O_2^{1-} D) N_2 E) N_2^{1-}

25.) Which of the following bonds gets weaker when the species shown is ionized?

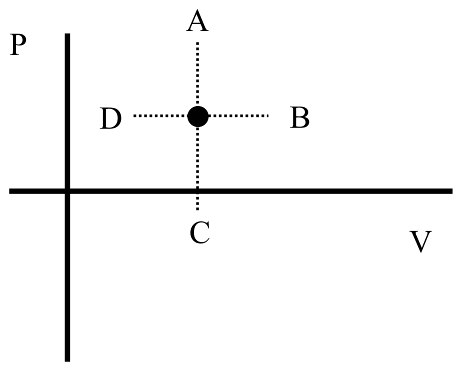
A) F_2 B) F_2^{1-} C) O_2^{1-} D) N_2 E) N_2^{1-}

26.) Which of the following is the least paramagnetic?

A) F_2 B) F_2^{1-} C) O_2^{1-} D) O_2 E) N_2^{1-}

SECTION 3: PROPERTIES OF IDEAL GASES

The point shown below lies on a plot of P vs. V for an ideal gas at 300K. For the next three questions you will describe the motion of the point in response to changing parameters. You can describe the motion of the point in two ways; (1) if the point would move along the axis A, B, C, or D then bubble in the single letter, or (2) if the point would move into one of the quadrants AB, AD, BC or DC then bubble in the two letters that describe the quadrant. Bubble in 'E' if the point would not move. Hint: You may find it helpful to first draw the plot through this point.



27.) How would the point move in response to an increase in pressure?

A) A B) B C) C D) D E) E

28.) How would the point move in response to an increase in volume?

A) A B) B C) C D) D E) E

29.) How would the point hop to a higher temperature isotherm at *constant pressure*?

A) A B) B C) C D) D E) E

Continue with the next question:

30.)A flask of fixed volume contains oxygen *atoms* at 3.00 atm pressure. What is the new pressure (atm) when all the atoms react to form O_3 molecules at constant temperature?

A) 1.00 B) 1.27 C) 1.50 D) 2.00 E) 2.27

31.) What is the new volume (L) when 1.00 L an ideal gas is heated at constant pressure from 100˚ C to 200˚ C?

A) 1.00 B) 1.27 C) 1.50 D) 2.00 E) 2.27

Consider a sample of one mole of propane (C_3H_6) gas in a closed 10.0 L flask at 110˚ C for the following three questions.

32.) What is the pressure (atm) of propane in the flask?

A) 1.00 B) 3.14 C) 15.7 D) 18.8 E) 20.4

33.) What is the pressure (atm) in the flask after the temperature is raised to 150˚ C?

A) 3.05 B) 3.47 C) 4.05 D) 4.89 E) 5.43

34.) If all the C_3H_6 were removed, what mass of oxygen in grams would have to be added at the original temperature to attain the original total pressure?

A) 1.0 B) 25 C) 32 D) 44 E) 56

Continue with the next question:

Consider a sample of one mole of propane gas (C_3H_6) *and five moles of oxygen (O_2) gas* in a closed 10.0 L flask at 110˚C for the following seven questions.

35.) What is the partial pressure (atm) of propane in the flask?

A) 1.00 B) 3.14 C) 15.7 D) 18.8 E) 20.4

36.) What is the partial pressure (atm) of oxygen in the flask?

A) 1.00 B) 3.14 C) 15.7 D) 18.8 E) 20.4

37.) What is the total pressure (atm) in the flask?

A) 1.00 B) 3.14 C) 15.7 D) 18.8 E) 20.4

38.) What is the ratio of root mean squared velocities of oxygen particles to propane particles in the flask (Hint: lots of stuff cancels in a ratio)?

A) 1.00 B) 1.15 C) 1.67 D) 1.83 E) 1.99

39.) What is the ratio of average molar kinetic energies of the oxygen and propane in the flask?

A) 1.00 B) 1.15 C) 1.67 D) 1.83 E) 1.99

40.) What is the coefficient for oxygen in the balanced chemical equation for the combustion of one (1) mole of C_3H_6 in oxygen to form carbon dioxide and water?

A) 1.5 B) 2.5 C) 3.5 D) 4.5 E) 5.5

41.)What is the total pressure (atm) in the flask if the combustion reaction goes to completion and the flask returns to 110˚ C (assume all species are gases) ?

A) 1.00 B) 3.14 C) 15.7 D) 18.8 E) 20.4

Continue with the next question:

42.)Which gas particles have the highest root mean squared velocity at 100˚ C?

A) He B) Ne C) Ar D) Kr E) Xe

For the next three questions, consider an atom gun that shoots atoms at a surface (a very simple model for the pressure of an ideal gas).

43.)What change(s) to the atomic gun model would increase the pressure on the surface (mark all that apply)?

A) Increase the mass of the particles.
B) Decrease the mass of the particles.
C) Increase the velocity of the particles.
D) Decrease the velocity of the particles.
E) Decrease the rate of fire (particles per second).

44.) Which change(s) in a sample of ideal gas would have the same effect as increasing the velocity of the particles of the atom gun (mark all that apply)?

A) Increase in temperature.
B) Increase in volume.
C) Decrease in pressure
D) Increase in the number of moles of gas.
E) None of these.

45.) Which change(s) in a sample of ideal gas would have the same effect as increasing the rate of fire (increase the number of particles per second) of the atom gun (mark all that apply and note that the velocity of the particles and rate of fire are different things)?

A) Increase in temperature.
B) Increase in volume.
C) Decrease in pressure.
D) Increase in the number of moles of gas.
E) None of these.