Midterm 2
March 7, 2011
(90 min, closed book)

Name:____________________

SID:______________________

TA Name:_________________

- There are 40 multiple choice questions worth 3 points each.
- Only answers on the Scantron form will be graded.
- You can tear off the equation sheet and the periodic table for your convenience.
- Scantron must be properly filled in and cannot contain any smudges or other marks. Scantrons will not be rescanned!
- You can use the page margin or the back of the pages as scratch paper.
- You can take the exam booklet with you after the exam.

Quantum:

$E = h\nu$

$\lambda\nu = c$

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

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

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

$\Delta x \, \Delta p \sim h$

$p = mv$

$E_n = h^2 n^2 / 8mL^2$; $n = 1, 2, 3...$

$E_v = (v + ½)\, hA/2\pi$; $A = (k/m)^{½}$

$E_n = n(n + 1)\, hB$; $B = h/8\pi^2 I$; $I = 2mr^2$

$m = m_A m_B/(m_A + m_B)$

Ideal Gas:

$PV = nRT$

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

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

Constants:

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

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

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

T (K) = T (C) + 273.15

F = 96,485 C / mol

1 V = 1 J / C

Gas Constant:

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

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

$1\ nm = 10^{-9}$ m

1 kJ = 1000 J

1 atm = 760 mm Hg = 760 torr ≈ 1 bar

1 L atm ≈ 100 J

Thermodynamics:

$\Delta G° = \Delta H° - T\Delta S°$

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

$\Delta S° = \sum S°$ (products) $- \sum S°$ (reactants)

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

$S = k_B \ln W$

$\Delta S = q_{rev}/T$

$\Delta E = q + w$

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

for $aA + bB \rightleftarrows cC + dD$

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

$\Delta G = \Delta G° + RT\ln Q$

$G = G° + RT\ln(a)$; a = activity $= \gamma P/P°$ or $\gamma[A]/[A]°$

$\Delta G° = - RT\ln K$

$\Delta G° = - nF\Delta\epsilon°$

$\Delta\epsilon = \Delta\epsilon° - (RT/nF) \ln Q$

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

$\Delta T = ik_{b,f}\, m$

$\Pi = iMRT$

$P_{total} = P_A + P_B = X_A P_A° + X_B P_B°$

Acid Base:

$pH = -\log[H_3O^+]$

$pX = - \log X$

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

Kinetics:

$[A]_t = [A]_0 e^{-kt}$

$\ln[A]_t = \ln[A]_0 - kt$

$t_{1/2} = \ln 2/k$

$1/[A]_t = 1/[A]_0 + kt$

$k = A\, e^{(-Ea/RT)}$

$\ln(k_1/k_2) = E_a/R\, (1/T_2 - 1/T_1)$

$t_{1/2} = 1/[A]_0 k$

$t_{1/2} = [A]_0/kt$

1. One 4p orbital can hold ___ electrons.
A. 1
B. 2
C. 6
D. 10
E. none of these
ANS: B

2. In many-electron atoms, the energies of the orbitals depend upon
A. n
B. l
C. m_l
D. n and l
E. n and m_l
ANS: D

3. Which of the following is <u>not</u> a *p*-block element?
A. K
B. Sn
C. Sb
D. At
E. More than one of these is not *p*-block elements.
ANS: A

4. The electron configuration for sulfur is
A. $1s^2 2s^2 2p^6 3s^2$
B. $1s^2 2s^2 2p^6 3s^2 3p^1$
C. $1s^2 2s^2 2p^6 3s^2 3p^4$
D. $1s^2 2s^2 2p^6 3s^2 3p^5$
E. none of these
ANS: C

5. All of the alkaline earth metals have the electron configuration __________ in their valence orbitals.
A. ns^1
B. ns^2
C. $ns^2 np^1$
D. $ns^2 np^5$
E. none of these
ANS: B

6. If the element with the electron configuration $[Rn]5f^{14}6d^{10}7s^2 7p^4$ existed, it would belong to which group?
A. boron group
B. carbon group
C. nitrogen group

D. oxygen group
E. halogens
ANS: D

7. For which of the following processes is $\Delta E = IE_1$?
A. $X^+(g) + e^- \rightarrow X(g)$
B. $X(s) \rightarrow X^+(s) + e^-$
C. $X(g) \rightarrow X^+(g) + e^-$
D. $X^+(g) \rightarrow X^{2+}(g) + e^-$
E. none of these
ANS: C

8. Which of the following theories correctly predicts the magnetic properties of molecular oxygen?
A. molecular orbital theory
B. valence bond theory
C. VSEPR theory
D. all of these
E. none of these

ANS: A

9. Which molecule contains a triple bond?
A. C_2H_4
B. CCl_4
C. H_2O
D. N_2
E. O_2
ANS: D

10. Which element is the most electronegative?
A. phosphorus
B. silicon
C. carbon
D. nitrogen
E. oxygen
ANS: E

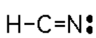
11. How many additional bonds are needed to complete the structure of the cyanide ion?: $C\text{-}N^-$
A. 0
B. 1
C. 2
D. 3
E. 4
ANS: C

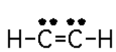
12. Rank the following in order of decreasing radius: K^+, Na^+, Cs^+, Rb^+
A. $K^+ > Na^+ > Cs^+ > Rb^+$
B. $Rb^+ > Cs^+ > Na^+ > K^+$
C. $Na^+ > K^+ > Rb^+ > Cs^+$
D. $Cs^+ > Rb^+ > K^+ > Na^+$
ANS: D

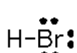
13. Select the element which never forms more than one bond in a Lewis Dot structure.
A. O
B. C
C. N
D. Al
E. H

ANS: E

14. Which bond is least polar?
A. C-C
B. C-N
C. N-H
D. C-F
E. C-O
ANS: A

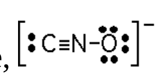
15. Which of the following Lewis structures does not contain an error?
A. 

B. 

C. 

D. They all do
E. None of them do
ANS: C

16. Write the singly bonded Lewis dot structure for BF_3. Which of the following statements best describes this structure?
A. It obeys the octet rule on all atoms.
B. It has less than an octet on at least one atom.
C. It has a lone pair of electrons on the boron atom.
D. It has less than an octet of electrons on all atoms.
E. It exceeds the octet rule.
ANS: B

17. What is the formal charge on the nitrogen atom in the Lewis structure,  ?
A. -2

B. -1
C. +1
D. +2
E. none of these
ANS: C

18. Which of the following should have a dipole moment?
A. CO_2
B. BCl_3
C. BrF_3
D. all of these
E. none of these
ANS: C

19. According to the VSEPR theory, which of the following should not be linear?
A. BeH_2
B. SO_2
C. CS_2
D. NNO
E. ICl
ANS: B

The following 2 questions are about the carbon atoms in this compound:

20. The molecular geometry at each of the carbons is __.
A. linear
B. trigonal planar
C. tetrahedral
D. trigonal pyramidal
E. bent
ANS: B

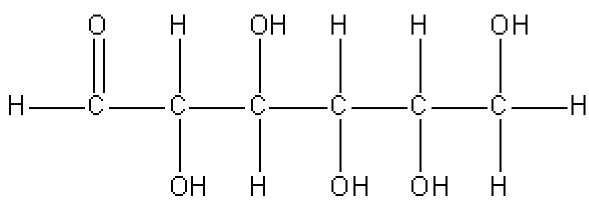
21. The hydridization at each of carbons is __.
A. sp
B. sp^2
C. sp^3
D. sp^3d
E. sp^3d^2
ANS: B

For the next two questions, assume the ionization energy of K is 417 kJ/mol and the electron affinity of F is -325 kJ/mol

22. What is the approximate net energy change in producing K^+ from K and F^- from F (kJ/mol)
A. 742
B. 147
C. -742
D. 92
E. -92
ANS: D

23. What is a possible net energy change in making the KF molecule?
A. 92
B. 742
C. -241
D. 0
E. 147
ANS: C

24. How many carbons in the structure shown below are NOT chiral?



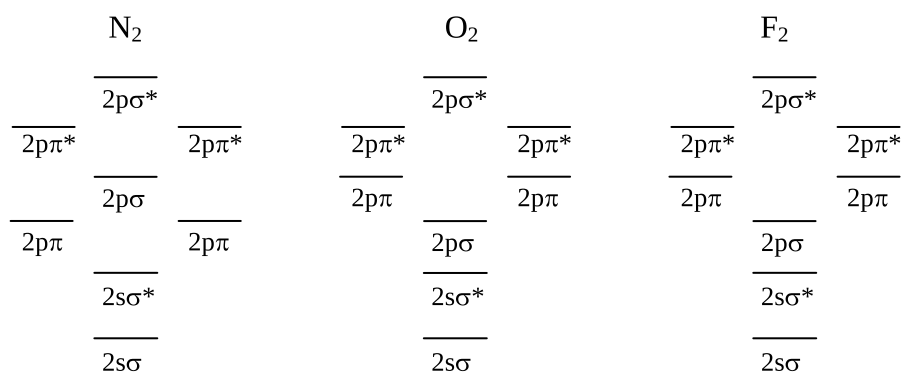
A. 6
B. 5
C. 4
D. 3
E. 2
ANS: E

25. Label the hybridization at C#1, C#2, C#3, and C#4 in the molecule.

	C1	**C2**	**C3**	**C4**
A.	sp	sp	sp^3	sp^3d
B.	sp	sp	sp^2	sp^3
C.	sp	sp^2	sp^2	sp^2

D. sp^2 sp^2 sp^3 sp^3
E. sp^3 sp^3 sp^3 sp^3
ANS: B

Consider the molecules and molecular ions of F_2, O_2 and N_2 to answer the following three questions (The relative energies of the molecular orbitals for each is shown. You need to fill in the electrons by yourself).



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

A. F_2^{2+}

B. F_2^{-}

C. O_2^{2-}

D. O_2^{-}

E. N_2

ANS: E.

27. Which of the following bonds gets weaker when the species shown are ionized?

A. F_2

B. F_2^{-}

C. O_2^{+}

D. N_2

E. N_2^{-}

ANS: D.

28. Which of the following is the most paramagnetic?

A. F_2

B. F_2^{2+}

C. O_2^-

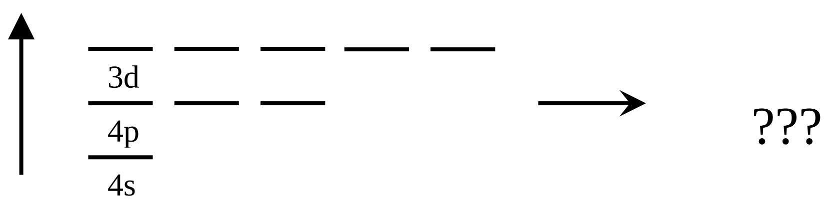
D. O_2^+

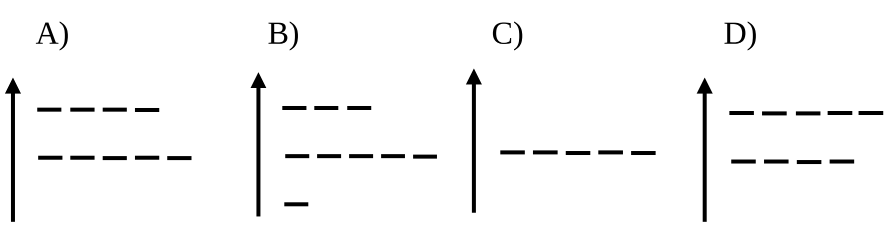
E. N_2^{2+}

ANS: B

29. Determine the hybridization around the central atom in SF_5^+
A. sp
B. sp^2
C. sp^3
D. sp^3d
E. sp^3d^2
ANS: D

30. Which is the energy diagram for the arsenic hybrid atomic orbitals in AsF_5 after hydridization?





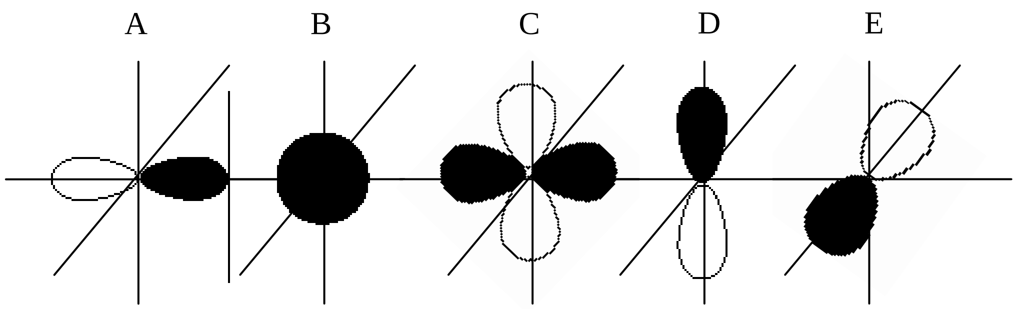
E) None of these

Answer: The solution to this problem lies in realizing that As atomic orbitals must be hybridized to sp3d in order to form bonds to 5 fluorine atoms. After hybridization, there should be 5 orbitals with equal energy corresponding to the sp^3d orbitals and 4 d orbitals remaining that were not hybridized. The only diagram that shows this combination of hybridized and unhybridized orbitals is choice A.

31. Which of the following species does not have resonance structures?
A. CO_3^{2-}
B. SO_2
C. H_2O
D. NO_3^-
E. O_3

ANS: C

For the next three questions, consider the following set of five orbitals:



32. How many nodes are displayed in orbital 'D'?

A. 0
B. 1
C. 2
D. 3
E. 4
ANS: B

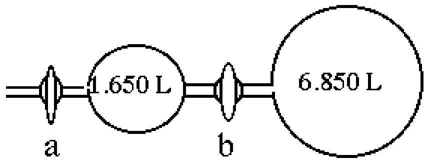
33. What is the best label for orbital 'A'?

A. 1s
B. 2s
C. 2p
D. 3s
D. 3p
ANS: C

34. Which orbital has the highest energy?

A. A
B. B
C. C
D. D
E. E
ANS: C

35. The apparatus pictured below is used to conduct the following experiment. After complete evacuation of both chambers, valve **b** is closed, and a sample of $CO_2(g)$ is introduced through valve **a**. When the pressure in the 1.650-L reservoir reaches 4.500 atm, valve **a** is closed. If valve **b** is now opened, allowing gas to flow into the 6.850-L reservoir, the final pressure of CO_2 in the apparatus (assuming no temperature change) will be



A. 0.8735 atm
B. 0.9226 atm
C. 1.084 atm
D. 1.428 atm
E. none of these

ANS: A

36. How many moles of methane (CH_4) are contained in a 35.0-L vessel at STP?
A. 0.488
B. 0.975
C. 1.95
D. 3.90
E. none of these

ANS: E

37. In a mixture of CO(*g*) and CO_2(*g*), the mole fraction of CO(*g*) (X_{CO}) is 0.115. If the pressure of the mixture is 2.50 atm, the partial pressure of CO_2 is
A. 0.288 atm
B. 1.25 atm
C. 2.21 atm
D. impossible to determine
E. none of these

ANS: C

38. An absorbance of 0.234 at 520 nm is measured for a 0.0100 M solution of compound X. The cuvette has a pathlength of 1.00 cm. What is the concentration of the compound X if the absorbance is 0.113?
A. 0.987 M
B. 0.113 M
C. 0.00520 M
D. 0.00482 M
E. 1.00 M
ANS: D

39. C_2H_2 is a compound you investigated in the experiment "How the nose knows". Each molecule of this compound contains
A. 2 σ bonds and 2 π bonds
B. 2 σ bonds and 3 π bonds
C. 3 σ bonds and 2 π bonds

D. 2 σ bonds and 1 π bond
E. 5 σ bonds and 0 π bond
ANS: C

40. In the experiment “Determination of the molarity of a strong acid”, if you titrated past the end point until the indicator turned yellow, how would that affect the calculated concentration of the HCl?

A. the concentration would be lower than the true value
B. the concentration would be higher than the true value
C. the concentration is not affected
D. the exact amount of HCl used is needed to decide how it affect the calculated concentration
E. none of the above is correct
ANS: A

hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

*Lanthanide series	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**Actinide series	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]