Review Sheet for Final Exam

To study for the exam, we suggest you look through the past review sheets, exams and homework assignments, and identify the topics that you most need to work on. To help with this, the table given below lists the topics covered in the course and the exam and review sheet questions on each of these topics. Once you've identified your weak spots, you can do practice problems etc. to get more comfortable with that material. To prepare for the multiple-choice questions, you may want to look back over the concept tests used in lecture.

We've also provided three long questions that are designed to help you see the connections between the various topics, and help you tie everything together into a coherent whole. The topics covered by these problems are shown in the last column of the table.

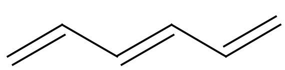
The questions on the exam will have a format similar to those on the hour exams. The exam will be about twice the length of an hour exam, and you will be given 3 hours.

Topic	**Review 1**	**Exam 1**	**Review 2**	**Exam 2**	**Review 3**	**Exam 3**	**Final Review**
Limiting Reagent Problems	1,4	1					
Empirical Formula Problems	2	2					
Molarity of solutions	3						
Relation between wavelength and frequency of a photon ($\nu\lambda=c$)		3					
Energy of a photon, and relation to energy levels ($\Delta E=h\nu$), color of molecules	5, 6	3			1	4c	2j
Bohr model of single electron atoms: calculating transition energies (i.e. energy, wavelength and frequency of a photon coming from a transition between energy levels), and ionization energies (energy required to remove the electron).	7						
Bohr model of many electron atoms: as for single electron atom but with Z replaced with Z_{eff}		5					1c,d
Particle in a box model: calculate energy levels and the properties (energy, wavelength, and frequency) of a photon absorbed or emitted by a transition between these energy levels. Most complex form of question is deriving a property of the model (i.e. mass of particle or length of box) from the properties of the photon.	9	6					2k
Photoelectric effect	8	4					1d
Quantum numbers (n,l,m) of atoms	10, 11						
Electron configurations of atoms	12	8					1a,b,e
Periodic trends for atoms: size (atomic radius), ionization potential, electron affinity, electronegativity	13, 14, 15	7					3
Predicting polarity (relative size of dipole moment) from electronegativities, and for different molecular structures	14	7	1f, 3e, 4e, 7	4	5		2c, 3
Lewis dot structures, including formal charges, oxidation numbers and resonance structures (don't forget to determine the structure that minimizes the formal charges)	16, 17		1a, 2, 3a	2		5	2b
Predicting bond order from Lewis dot structures (including resonance effects where appropriate)			1b,d, 3c	3d, e			
Determining coordinate number, hybridization of atoms in molecules and geometry (from VSEPR theory)			1c, 3b, 4b	2, 6a			2b
Molecular orbitals for sigma bonds			1e	6b			

Molecular orbitals for pi-electron systems			3d, 4c,e	3b, c			2h,i
Line drawings of molecules (filling in hydrogens)			4a	3a			2a
Diatomic molecules: molecular orbitals, bond order, paramagnetism			5	1			
Triatomic molecules: pi orbitals			6				
Molecular forces (dispersion, dipole-induced dipole, dipole-dipole, H-bond, ion-induced dipole, ion-dipole, ion-ion)			8	4, 5	5, 6		2d,e 3
Hydrophobic vs. Hydrophilic molecules/ solubility in polar vs. nonpolar solvents			9	4, 5	5, 7, 8. 9	3	2f,g 3
Transition metal complexes: drawing d orbitals and occupations, predicting paramagnetism, spectrochemical series					1,3	2, 4a, 4b, 4d, 5	1f,g,h
Transition metal complexes: isomers (enantiomers and diastereomers)					2	1	1 i,j
Transition metal complexes: inner sphere vs. outer sphere ligands					4	1	
Solids: unit cell for cubic, body-centered cubic and fcc lattice; counting atoms in a unit cell; close packing (fcc vs. hcp); and determining coordination numbers.					10, 11	6	

1) a) What is the electronic configuration of Cobalt, Co?
b) What is the electronic configuration of Cobalt, Co^{+1}?
c) Using Z_{eff} =0.4, predict the ionization potential of Co.
d) A photon with λ=255nm ejects an electron from a Cobalt atom. What is the kinetic energy of the ejected electron?
e) What is the electronic configuration of Co^{+3}?
f) Sketch the d-orbitals and electron occupations for $Co^{+3}(NH_3)_6$.
g) Sketch the d-oribitals and electron occupations for $Co^{+3}(OH_2)_6$. If $Co^{+3}(OH_2)_6$ is red, what is the splitting (in kJ/mol) between the d-orbitals (Δ_o)?
h) Are either $Co^{+3}(NH_3)_6$ or $Co^{+3}(OH_2)_6$ paramagnetic?
i) Draw all isomers of $Co^{+3}(NH_3)_3(OH_2)_3$.
j) Draw all isomers of $Co^{+3}(NH_3)_2(OH_2)_4$.

2) a) Consider the molecules

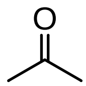
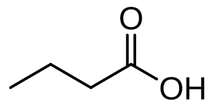
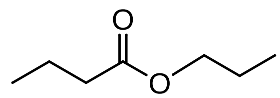
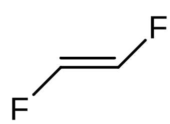
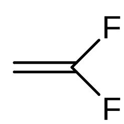


hexatriene

hexane

a) What is the molecular formula of each of these molecules?
b) What is the hybridization of each of the carbon atoms?
c) Does hexatriene have a dipole moment? Does hexane have a dipole moment?
d) When placed next to a Sodium ion (Na^+), which would have a larger induced dipole moment, hexatriene or hexane?
e) Which would have larger dispersion interactions, two hexatriene molecules or two hexane molecules?
f) Is hexatriene hydrophobic or hydrophilic? Which would be more hydrophobic hexatriene or hexane?
g) Which of the following would be a better solvent for hexane: water, acetone ($(CH_3)_2C{=}O$) or ethyl ether ($CH_3CH_2OCH_2CH_3$)?
h) How many pi molecular orbitals are there for hexatriene? How many of these orbitals are filled?
i) Sketch the highest occupied molecular orbital and lowest unoccupied molecular orbitals for this molecule.
j) A photon with λ=350nm can promote an electron from the high occupied molecular orbital to the lowest unoccupied molecular orbital. What is the different in energy between these orbitals (in kJ/mol)?
k) Suppose we wanted to model this system as a particle in a box. In this model, a photon with λ=350nm promotes the particle from the n= 3 to n=4 level. What must the energy difference be between the n=3 and n=4 levels ($E_{n=4}-E_{n=3}$) for a transition between these levels to arise from a photon with λ=350nm? Lets assume the particle is in a 12Angstrom box. What must the mass of the particle be to obtain this value for ($E_{n=4}-E_{n=3}$)?

3) Circle the best answer to the following statements.

Lower Ionization Energy	K	Ca
Greater solubility in acetone, 		
Higher Electron Affinity	Br	Cl
Higher boiling point	CH_3NH_2	$CH_3CH_2CH_2CH_2NH_2$
Smaller atomic radius	S	Te
Larger bond dipole	CO	NO
Oxidation state of Mn in MnO_2	+II	+IV
Hybridization of N in NH_3	sp^2	sp^3
Nonpolar molecule		

Useful constants, formulas, and a periodic table.

$h = 6.626076 \times 10^{-34}$ J s
$m_e = 9.109390 \times 10^{-31}$ kg
$c = 2.99792458 \times 10^{8}$ m s^{-1}
1 rydberg = 2.18×10^{-18} J
1 eV = 1.602×10^{-19} J

$r_n = (n^2/Z)\, a_o \quad a_o = 0.529$Angstroms
$E_n = h^2n^2/(8\ m\ L^2)$