

**KWANTLEN UNIVERSITY COLLEGE**

**DEPARTMENT OF CHEMISTRY**

**Final Examination: CHEM 1110**

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

April 19, 2002

Time: 3 hours

**INSTRUCTIONS:**

1. Show all calculations in order to receive any credit.
2. A periodic table will be given to you.
3. Rough work should be done on the back of the pages.
4. Be sure this exam paper has 10 pages.

**ADDITIONAL INFORMATION:**

$R = 0.08206 \text{ L-atm/mol-K}$

Planck's constant =  $h = 6.62 \times 10^{-34} \text{ Joule-s}$

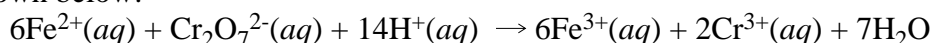
speed of light =  $c = 3.0 \times 10^8 \text{ m/s}$

Avogadro's number =  $6.02 \times 10^{23}$

1 atm = 760 mm Hg

PAGE	MARKS	
2	17	
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8	26	
9	18	
10	9	
Bonus	5	
TOTAL	155	

1. (5) A sample of solid  $[(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot \text{XH}_2\text{O}]$  of mass 5.882 g was dissolved in water and oxidized completely by reacting with exactly 25.00 mL of 0.1000 M  $\text{K}_2\text{Cr}_2\text{O}_7$  according to the balanced net ionic equation shown below:



Determine the value of X in  $[(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot \text{XH}_2\text{O}]$ .

2. (2) A 1.520 g sample of a nitrogen oxide was found to contain 0.463 g of nitrogen. The empirical formula for this oxide of nitrogen is:  
(a)  $\text{N}_2\text{O}$  (b)  $\text{NO}$  (c)  $\text{N}_2\text{O}_3$  (d)  $\text{NO}_2$  (e)  $\text{N}_2\text{O}_5$
3. (2) 12.21 g of an unknown gas is sealed in a 1.0 L flask at  $97^\circ\text{C}$  and 3.75 atm. Which one of the following is most likely to be the unknown gas?  
(a)  $\text{H}_2\text{S}$  (b)  $\text{HBr}$  (c)  $\text{CO}_2$  (d)  $\text{COCl}_2$  (e)  $\text{C}_2\text{H}_2$
4. (2) Calculate the density in g/L of  $\text{H}_2\text{S}$  gas at  $20^\circ\text{C}$  and 0.80 atm pressure.  
(a) 0.60 (b) 1.13 (c) 16.6 (d) 46.0 (e) 2.17
5. (2) Calculate the wavelength of photons having an energy of 180 kJ/mol.  
(a)  $6.64 \times 10^{-13}$  nm (b)  $3.98 \times 10^{26}$  nm (c)  $1.10 \times 10^{-21}$  nm  
(d) 664 nm (e)  $6.64 \times 10^{-7}$  nm
6. (2) How many orbitals in an atom can have  $n = 5$ ?  
(a) 5 (b) 9 (c) 10 (d) 25 (e) 50
7. (2) How many electrons in the ground state of a Hg atom can have the quantum number  $m_\ell = +1$ ?  
(a) 8 (b) 10 (c) 12 (d) 14 (e) 16

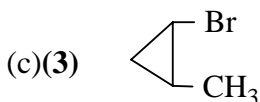
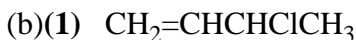
8. For H-like species the energy of an electron in any given orbit can be calculated from the formula,

$$E_n = \frac{-2.178 \times 10^{-18} Z^2}{n^2} \text{ (Joule)}$$

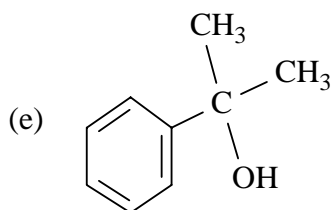
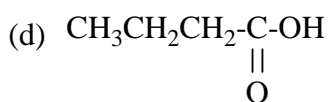
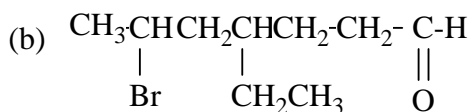
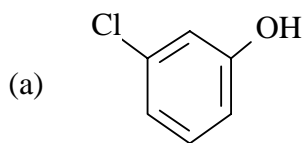
- (a) **(4)** Calculate the energy and frequency for the transition from the  $n = 3$  to  $n = 2$  transition in the  $\text{Li}^{2+}$  ion.
- (b) **(4)** Calculate the ionization energy (in kJ/mol) for the  $\text{He}^+$  ion if the electron is in the ground state.

9. **(3)** Consider the electronic transitions in the H-atom from the  $n = 6$  orbit to all the lower orbits in answering the following questions:
- (a) The transition from  $n = \underline{\hspace{1cm}}$  to  $n = \underline{\hspace{1cm}}$  should produce the photon with the greatest frequency.
- (b) The transition from  $n = \underline{\hspace{1cm}}$  to  $n = \underline{\hspace{1cm}}$  should produce the photon with the smallest frequency.
- (c) The transition from  $n = \underline{\hspace{1cm}}$  to  $n = \underline{\hspace{1cm}}$  should produce the photon whose wavelength is most likely found in the visible region.

10. (2) Which element has the following valence electron configuration  $6s^26p^2$ ?  
(a) Sn (b) Sb (c) Pb (d) Bi (e) Te
11. (2) How many unpaired electrons does a  $Mn^{3+}$  ion have?  
(a) 5 (b) 4 (c) 3 (d) 2 (e) 1
12. (2) The phosphide ion  $P^{3-}$  is isoelectronic with which one of the following?  
(a)  $O^{2-}$  (b)  $F^-$  (c)  $Na^+$  (d)  $Al^{3+}$  (e)  $K^+$
13. (2) Which element has the smallest atomic radius?  
(a) F (b) Al (c) S (d) P (e) Si
14. (2) Which ion has the smallest radius?  
(a)  $Na^+$  (b)  $K^+$  (c)  $Ca^{2+}$  (d)  $Mg^{2+}$  (e)  $F^-$
15. (2) Which of the following atoms would have the most negative electron affinity value?  
(a) Ar (b) Cl (c) Br (d) K (e) P
16. (2) Which element will have the smallest first ionization energy?  
(a) Li (b) Ga (c) K (d) Bi (e) As
17. (2) Which element has the highest electronegativity?  
(a) As (b) Cl (c) Ga (d) P (e) Br
18. (2) Which element will have the largest second ionization energy?  
(a) Li (b) Mg (c) O (d) S (e) Ca
19. (2) Which of the following covalent bonds is the most polar?  
(a) Al-I (b) Si-I (c) Al-Cl (d) Si-Cl (e) Si-P
20. For each compound, if *cis-trans* isomerism is possible draw the isomers, and if optical isomerism is possible label all chiral (asymmetric) carbon atoms with an asterisk (\*).



21. (10) Name the following, using IUPAC or other acceptable names:



22. (10) Draw structures for the following:

(a) *cis*-3,4-dichlorocyclopentanone

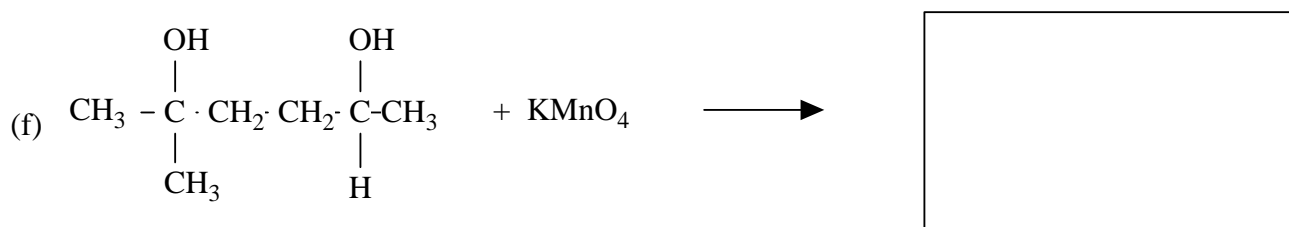
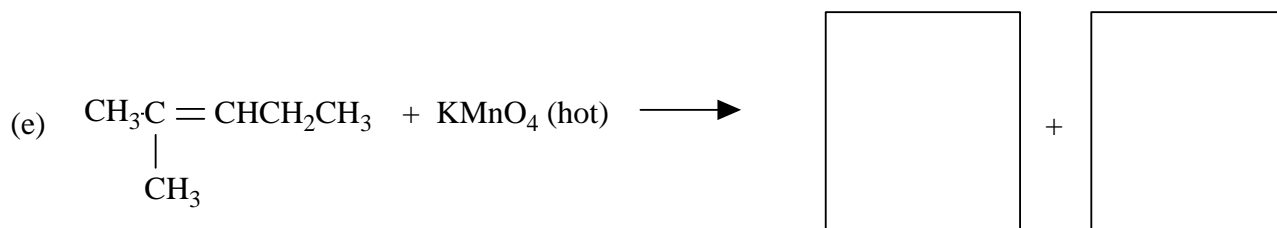
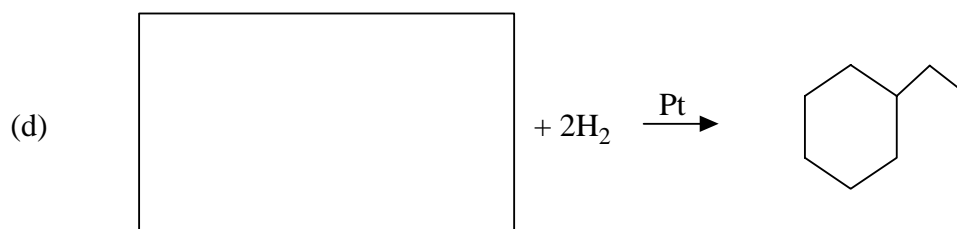
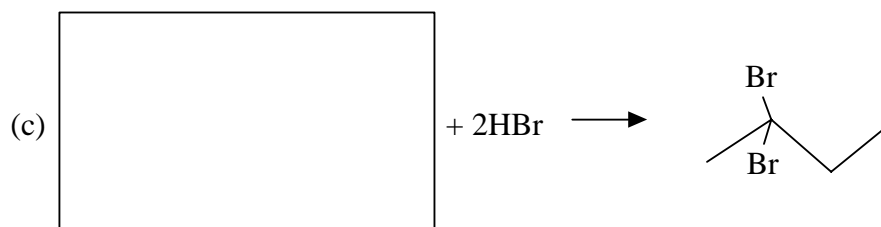
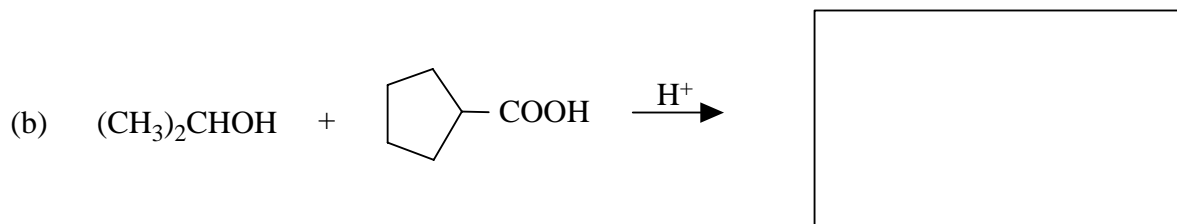
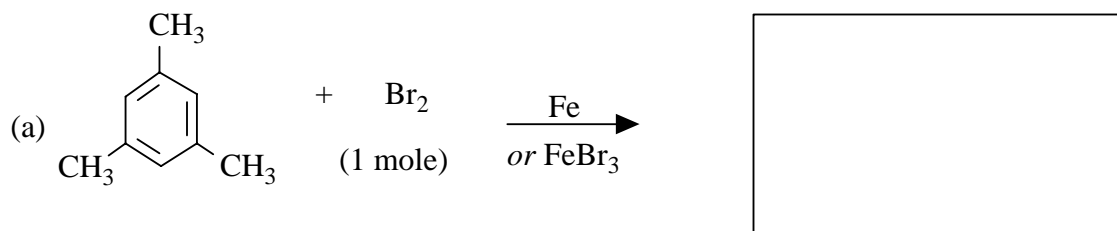
(b) isobutyl benzoate *or* 2-methylpropyl benzoate

(c) 2,4-dinitroethylbenzene

(d) 3,5,5-trimethyl-4-propylnonane

(e) *trans*-4,4,7-trimethyl-6-ethyl-2-octene

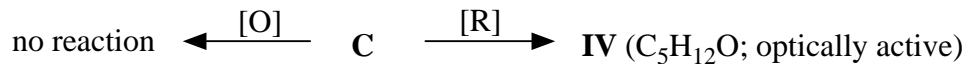
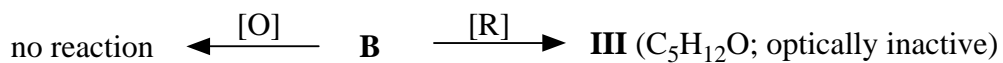
23. (14) Draw the structure(s) for the organic reactant(s) *or* product(s) in each case.



24. (a)(7) Draw the **7** isomers of  $C_5H_{10}O$  which have a ketone or aldehyde functional group.

(b)(7) Assign structures to **A**, **B** and **C**, three of the isomers referred to in part (a), and to their numbered reaction products (**I** to **IV**) on the basis of the data given below. ([O] = reaction with  $KMnO_4$  and [R] = reaction with  $H_2$  and Pt).

**A** is optically active but **B** and **C** are not. **A** gives a silver mirror with the Tollens reagent but **B** and **C** do not.



25. (2) According to the VSEPR theory the geometry of the  $\text{TlCl}_3$  is best described as:  
(a) trigonal pyramidal (b) trigonal planar  
(c) tetrahedral (d) T-shaped  
(e) square planar
26. (2) According to the VSEPR theory the geometry of the  $\text{Cl}_3\text{AsO}$  molecule is best described as:  
(a) square planar (b) see-saw shaped  
(c) trigonal bipyramidal (d) tetrahedral  
(e) square pyramidal
27. (2) The bond angle in  $\text{O}_3$  is expected to be approximately:  
(a)  $90^\circ$  (b)  $120^\circ$  (c)  $145^\circ$  (d)  $180^\circ$  (e)  $109.5^\circ$
28. (2) According to the VSEPR theory, the Cl-Se-Cl bond angles in the  $\text{SeCl}_4$  molecule are predicted to be:  
(a)  $109.5^\circ$  (b)  $90^\circ$  and  $120^\circ$  (c)  $180^\circ$  (d)  $< 109.5^\circ$  (e)  $< 90^\circ$  &  $< 120^\circ$
29. (2) What is the hybridization on the central atom in the  $\text{SO}_3^{2-}$  ion?  
(a) sp (b)  $\text{sp}^2$  (c)  $\text{sp}^3$  (d)  $\text{sp}^3\text{d}$  (e)  $\text{sp}^3\text{d}^2$
30. (2) What is the hybridization on the central atom in  $\text{SnCl}_3^+$ ?  
(a) sp (b)  $\text{sp}^2$  (c)  $\text{sp}^3$  (d)  $\text{sp}^3\text{d}$  (e)  $\text{sp}^3\text{d}^2$
31. (2) Which one of the following is a polar molecule?  
(a)  $\text{AsF}_5$  (b)  $\text{GeCl}_4$  (c)  $\text{GaCl}_3$  (d)  $\text{XeO}_4$  (e)  $\text{SF}_4$
32. (2) What is the bond order for  $\text{N}_2^+$ ?  
(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0 (e) 2.5
33. (2) What is the bond order for  $\text{O}_2^{2-}$ ?  
(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5 (e) 3.0
34. (2) Which of the following is paramagnetic?  
(a)  $\text{H}_2$  (b)  $\text{Li}_2$  (c)  $\text{B}_2$  (d)  $\text{C}_2$  (e)  $\text{C}_2^{2-}$
35. (2) Which of the following would have the shortest bond length?  
(a)  $\text{O}_2$  (b)  $\text{O}_2^+$  (c)  $\text{O}_2^-$  (d)  $\text{O}_2^{2-}$
36. (2) Which of the following would have the largest bond energy?  
(a)  $\text{O}_2$  (b)  $\text{O}_2^+$  (c)  $\text{O}_2^-$  (d)  $\text{O}_2^{2-}$
37. (2) How many sigma and pi bonds are there in a molecule of  $\text{NCCN}$ ?  
(a) 3 sigma bonds (b) 3 sigma bonds and 2 pi bonds  
(c) 4 sigma and 2 pi bonds (d) 4 sigma and 3 pi bonds  
(e) 3 sigma and 4 pi bonds

38. (4) The measured O-N-O bond angles are  $180^\circ$  in  $\text{NO}_2^+$ ,  $134^\circ$  in  $\text{NO}_2$ , and  $115^\circ$  in  $\text{NO}_2^-$ . Account for this trend.

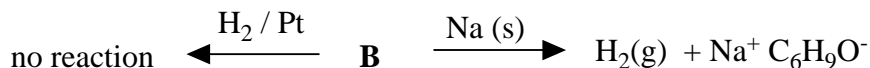
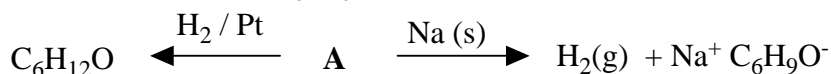
39. (2) Assume that you have an unlabeled bottle containing a white crystalline powder. The powder melts at  $310^\circ\text{C}$ . You are told that it is either,  $\text{SO}_3$ ,  $\text{CCl}_4$ ,  $\text{BrCl}$ , or  $\text{NaNO}_3$ . Which do you think that it is? Explain your choice.

40. (6) Write the Lewis dot structures, including formal charges as well as resonance forms as requested for each of the following:

(a)  $\text{HPO}_3^{2-}$  (show three resonance structures and circle the most probable)

(b)  $\text{FCIO}_3$  (show three resonance structures and circle the most probable)

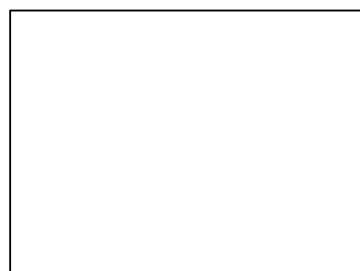
41. (6) There are more than 150 isomers of  $\text{C}_6\text{H}_{10}\text{O}$ . Give one possible structure for **A**, one for **B**, and one for **C** having the formula  $\text{C}_6\text{H}_{10}\text{O}$  which give the following reactions:



**A**

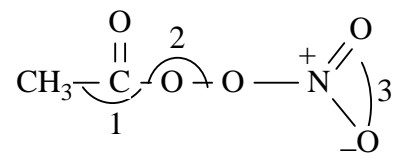


**B**



**C**

42. One of the constituents of photochemical smog is peroxyacetyl nitrate, PAN. It has the structure shown below.



(a) (1) How many sigma bonds are there in this molecule? \_\_\_\_\_

(b) (1) How many pi bonds are there in this molecule? \_\_\_\_\_

(c) (3) Give the approximate values of the angles labeled, 1,2,3.

Angle #1 \_\_\_\_\_ Angle #2 \_\_\_\_\_ Angle #3 \_\_\_\_\_

(d) (1) How many non-bonding (lone) pairs of electrons are in this structure? \_\_\_\_\_

(e) (3) Determine the number of atoms and the total number of hybrid orbitals used by these atoms in the above molecule.

Number of atoms using  $sp^3$  hybrid orbitals is \_\_\_\_\_

Total number of  $sp^3$  hybrid orbitals used is \_\_\_\_\_

Number of atoms using  $sp^2$  hybrid orbitals is \_\_\_\_\_

Total number of  $sp^2$  hybrid orbitals used is \_\_\_\_\_

Number of atoms using  $sp$  hybrid orbitals is \_\_\_\_\_

Total number of  $sp$  hybrid orbitals used is \_\_\_\_\_

### BONUS QUESTION (5)

The bond angle H-O-H in water is  $104.5^\circ$ , the C-O-H bond angle in methanol is  $109^\circ$ , and the C-O-C bond angle in dimethyl ether is  $112^\circ$ . Explain the differences between the above observed bond angles and the expected bond angles.