BROCK UNIVERSITY

Progress Examination, December 2003
Course: Chemistry 1F92
Date of Examination: 16 December 2003
Time of Examination: 19:00 - 22:00

Number of Pages: 16
Number of Students: 460
Number of Hours: 3
Instructor: M. F. Richardson MFR JKA

DO NOT FORGET TO FILL THIS IN

YOUR NAME _____

STUDENT NUMBER _____

LAB DAY AND TIME _____

INSTRUCTIONS: Non-programmable calculators and model kits are allowed. A periodic table is provided at the end of this examination. Important physical constants and formulas are given below.

No examination aids other than those specified are permitted. Use or possession of unauthorized materials will automatically result in the award of a zero grade for this examination.

Answer all questions on this examination paper and turn it in at the completion of the exam.

SHOW ALL WORK. GIVE UNITS.

Useful formulas and constants:

$E = h\nu = hc/\lambda$

$h = 6.6256 \times 10^{-34}$ J s

$c = 2.998 \times 10^{8}$ m/s

$E_n = -R_H(1/n^2)$ = energy of an electron in nth shell of Hydrogen

$R_H = 2.18 \times 10^{-18}$ J

Avogadro's Number: 6.022×10^{23}

1	_____	/ 5
2	_____	/ 10
3	_____	/ 10
4	_____	/ 11
5	_____	/ 3
6	_____	/ 6
7	_____	/ 10
8	_____	/ 8
9	_____	/ 10
10	_____	/ 5
11	_____	/ 6
12	_____	/ 8
13	_____	/ 8
BONUS	_____	/ 5
TOTAL	_____	/100

1. (5 marks) Recently a transport truck was involved in an accident, destroying its cargo. The truck was carrying 128 barrels of pills from a major Canadian pharmaceutical company. Each cylindrical barrel was 1.5 m high and 0.80 m in diameter. Each pill had a volume of 190 mm^3, and a value of \$0.035. Calculate the value of the pills destroyed in the accident.

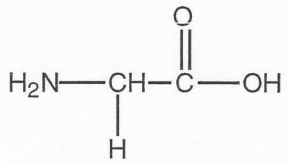
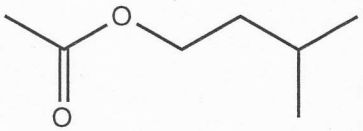
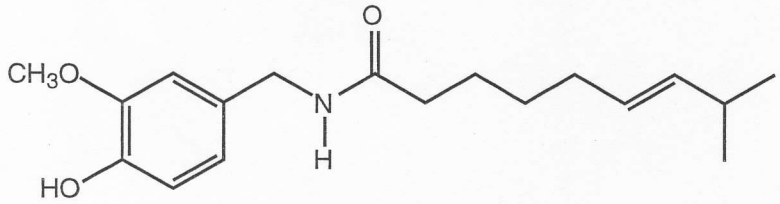
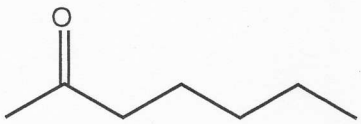
Remember that the volume of a cylinder is $\pi r^2 h$, where π is 3.14159, r is the radius of the cylinder, and h is the height.

2. (10 marks) We have studied the following classes of organic compounds in this course:

alcohols	alkynes	carboxylic acids
aldehydes	amides	esters
alkenes	amines	ethers
alkyl halides	aromatic compounds	ketones

For each of the molecules following:

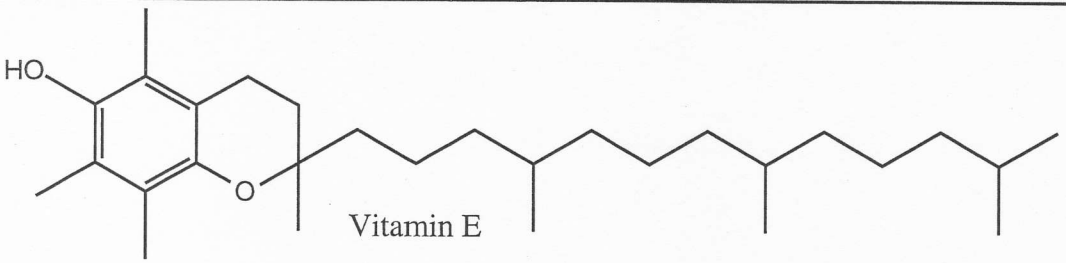
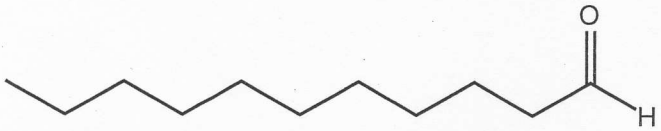
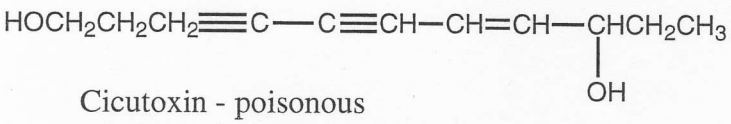
- **state all of the class(es)** (as defined on page 3) that each compound belongs to. Some molecules may belong to only one class of compounds, others may belong to several
- **circle** the functional groups characteristic of the classes
- Place a **star** (*) on **each** chiral carbon.

Compound	Class(es)
	
 Gives bananas their characteristic taste and smell	
 Capsaicin (responsible for "hot" in hot chili peppers)	
 (alarm pheromone of bees)	

Question 2 (continued)

For each of the molecules following:

- **state all of the class(es)** (as defined on page 3) that each compound belongs to. Some molecules may belong to only one class of compounds, others may belong to several
- **circle** the functional groups characteristic of the classes
- Place a **star** (*) on **each** chiral carbon.

Compound	Class(es)
 Vitamin E	
 sex pheromone of the greater wax moth	
 Cicutoxin - poisonous substance in water hemlock	

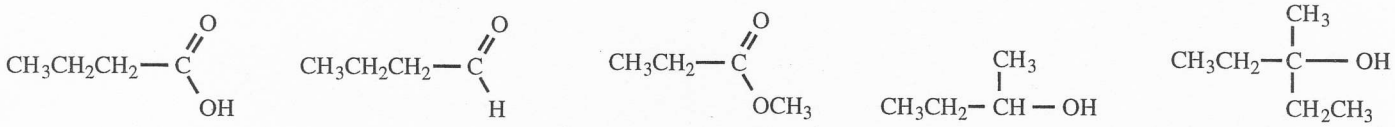
3. (10 marks) Draw structures for the following compounds.

(a) **all** primary amines with formula $C_4H_{11}N$

(b) **all** ketones with the formula $C_5H_{10}O$

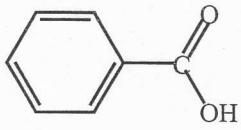
(c) **all** esters and carboxylic acids with the formula $C_5H_{10}O_2$

4. (11 marks) (a) (5 marks) You have an unknown that could be one of the following compounds:

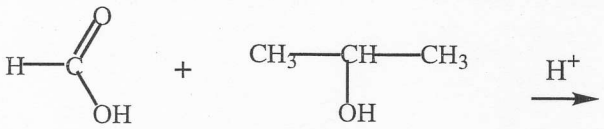


Suppose that your unknown tests neutral with pH paper. It reacts with sodium metal but not with aqueous potassium permanganate. Which of the compounds listed above is it? **Circle** the compound.

(b) (6 marks) Draw structures for the organic products of the following reactions:

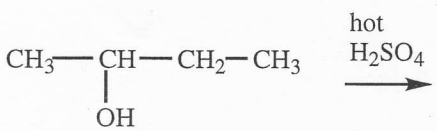
(i) NaOH +  ⟶

(ii) $CH_3CH_2CH{=}CH_2 + HBr \longrightarrow$

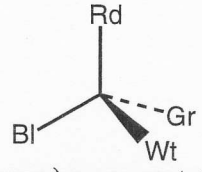
(iii) 

(iv) $(CH_3)_2CHOH + KMnO_4 \longrightarrow$

(v) $CH_3NH_2 + CH_3CO_2H \longrightarrow$
(reaction at room temperature)

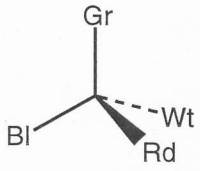
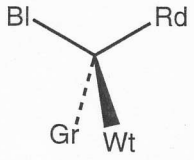
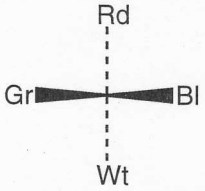
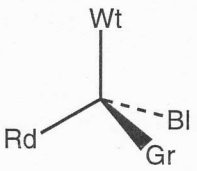
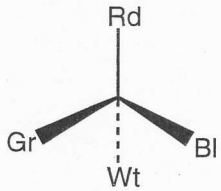
(vi) 

5. (3 marks). Consider the structure



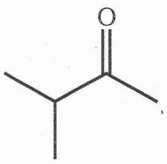
where Wt (white), Bl (blue), Rd (red), and Gr (green) represent different groups attached to a tetrahedral carbon. You can build a model of this with a tetrahedral carbon and white, blue, green and red spheres.

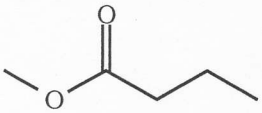
Which **ONE** of the following structures represents the mirror image of the one shown above?

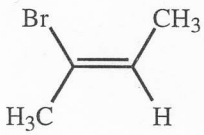
 (a)	 (b)	 (c)	 (d)	 (e)

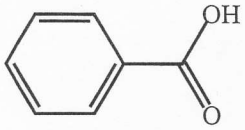
Answer (give letter): _____

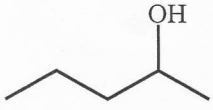
6. (6 marks). Give names (common or IUPAC) for the following organic compounds:

(a)  _____

(b)  _____

(c)  _____

(d)  _____

(e)  _____

(f) $(CH_3CH_2)_2NH$ _____

7. (10 marks) A compound contains the elements C, H, and O. Assume that 11.50 grams of the compound is burned in air to produce 21.79 g CO_2 and and 7.137 g H_2O. What is the empirical formula of the compound?

8. (8 marks) (a) (1 mark) Which element will show an unusually large jump in ionization energy values between I_4 and I_5, the 4th and 5th ionization energies?

Ca Fe Al Si P **Answer:** _____

(b) (1 mark) Which of the following equations represents the second ionization energy of oxygen?

A. $O^{2-}(g) \rightarrow O^{-}(g) + e^{-}(g)$

B. $O^{+}(g) \rightarrow O^{2+}(g) + e^{-}(g)$

C. $O^{2-}(g) \rightarrow O(g) + 2\,e^{-}(g)$

D. $O(g) + 2\,e^{-}(g) \rightarrow O^{2-}(g)$

E. $O(g) \rightarrow O^{2+}(g) + 2\,e^{-}(g)$

Answer (give letter): _____

(c) (1 mark) Give two cations that are isoelectronic to the fluoride ion. **Answer:** _____

(d) (1 mark) Give two anions that are isoelectronic to the rubidium ion **Answer:** _____

(e) (2 marks) Use periodic trends and predict which of the following ions has the largest radius and which the smallest:

F^{-} Mg^{2+} Cl^{-} K^{+} Na^{+}

Answers: Largest radius. _____

Smallest radius. _____

(f) (2 marks) Give the electronic configurations of a manganese atom and a Mn^{3+} ion.

Mn _____ Mn^{3+} _____

The manganese atom has _____ unpaired electrons. The Mn^{3+} ion has _____ unpaired electrons.

9. (5 marks) Give names for the following compounds

(a) $HClO_4$ (aq)

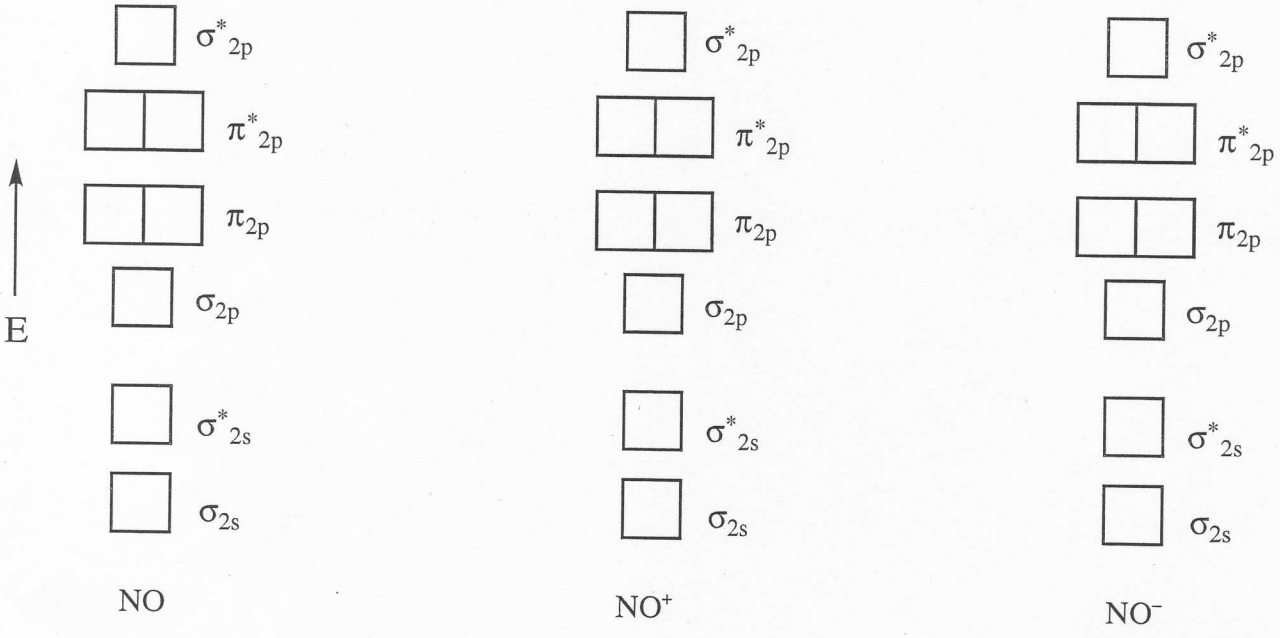
(b) $CuNO_2$

(c) $KHCO_3$

(d) $Fe_3(PO_4)_2$

(e) $(NH_4)_2SO_4$

10. (5 marks) Below is the molecular energy level diagram for the valence orbitals in the NO molecule.



(a) Complete the diagrams above for NO, NO^+, and NO^-.

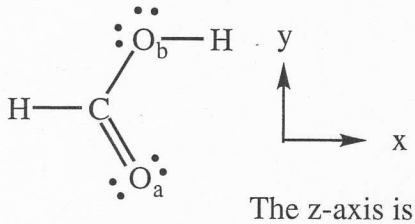
(b) What is the bond order for each species?

NO _____ NO^+ _____ NO^- _____

(c) Which species has the strongest bond? _____

(d) Which species is/are paramagnetic? _____

11. (6 marks) Formic acid has the following Lewis structure:



The z-axis is perpendicular to the plane of the paper

(a) What are the ideal bond angles?

C-O_b-H bond angle = _____ H-C-O bond angles = _____

(b) What are the hybridizations of the C and O atoms?

The hybridization of C is _____, of O_a is _____, and of O_b is _____.

(c) (2 marks) Draw diagrams to show how the sigma (σ) bonds are formed in formic acid. Label your drawings with the names of the hybrid orbitals on C and O, and the name of the atomic orbitals on H.

(d) (2 marks) Make a perspective drawing to show how the pi (π) bond is formed in formic acid. Label the orbitals that form the pi bond.

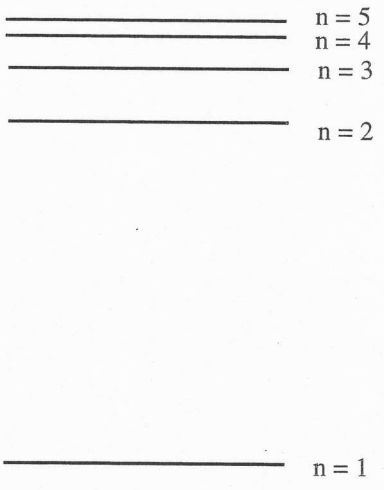
12. (8 marks) For each of the molecules and ions shown below:

- Draw the Lewis structure
- Give the electron count for each species. **Lewis structures will not be marked if the electron count is incorrect.**
- State the hybridization of the central atom, the electron-pair geometry about the central atom and the geometry of the molecule or ion in the spaces provided.

ClO_3^- No. of valence electrons _____ Hybridization of central atom _____ Electron-pair geometry _____ Molecular geometry _____	CO_3^{2-} No. of valence electrons _____ Hybridization of central atom _____ Electron-pair geometry _____ Molecular geometry _____
ClF_4^+ No. of valence electrons _____ Hybridization of central atom _____ Electron-pair geometry _____ Molecular geometry _____	BrF_4^- No. of valence electrons _____ Hybridization of central atom _____ Electron-pair geometry _____ Molecular geometry _____

13. (8 marks)

(a) (3 marks) The diagram on the right represents the quantum levels of a hydrogen atom (approximately to scale).



(i). Considering only the five levels shown, how many different electronic transitions are possible when electromagnetic radiation is emitted by a hydrogen atom? _____

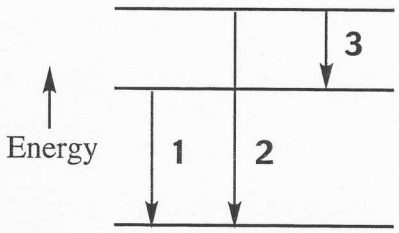
(ii). Which transition will have the lowest energy?

n = _____ to n = _____ .

(iii). Which transition will have the highest frequency?

n = _____ to n = _____ .

(b) (5 marks) The diagram on the right shows three possible electronic transitions for an atom of an unknown element. Use the information given in the diagram and on page 1 of the exam, and determine the wavelength associated with Transition 3.



Transition 1:
$\lambda = 682$ nm

Transition 2:
$\lambda = 432$ nm

BONUS QUESTION (5 MARKS).

Build a model of the amino acid glycine, $H_2NCH_2CO_2H$, and turn it in in the plastic bag provided. Remember that red pieces represent oxygen and blue pieces represent nitrogen. Use white spheres for hydrogen. **Be sure to fill out the slip of paper in the bag with your name and lab day and enclose it with your model in the bag.**

PERIODIC TABLE OF THE ELEMENTS

Brock University 2003

Atomic Number → 3
Li ← Element symbol
Atomic Weight → 6.941

1A 1												3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H 1.008	2A 2																2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn 222
87 Fr (223)	88 Ra (226)	89 Ac** (257)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110	111	112	113	114	115	116	117	118

58 Ce 140.1	59 Pr 140.9	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.25	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

*Lanthanide Series

**Actinide Series