NAME (Print): _____

SIGNATURE: _____

Chemistry 320M/328M
Dr. Brent Iverson
2nd Midterm
October 26, 2017

Please print the first three letters of your last name in the three boxes

Please Note: This test may be a bit long, but there is a reason. I would like to give you a lot of little questions, so you can find ones you can answer and show me what you know, rather than just a few questions that may be testing the one thing you forgot. **I recommend you look the exam over and answer the questions you are sure of first**, then go back and try to figure out the rest. Also make sure to **look at the point totals** on the questions as a guide to help budget your time.

You cannot use a red pen to take the exam. You must have your answers written in PERMANENT ink if you want a regrade!!!! This means no test written in pencil or ERASABLE INK will be regraded.

Please note: We routinely xerox a number of exams following initial grading to guard against receiving altered answers during the regrading process.

FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENCTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!

Page	Points	
1		(23)
2		(30)
3		(28)
4		(18)
5		(12)
6		(24)
7		(22)
8		(30)
9		(-)
10		(21)
11		(21)
12		(15)
13		(16)
14		(13)
Total		(273)

Student Honor Code

"As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity."

_____

(Your signature)

PERIODIC TABLE OF THE ELEMENTS

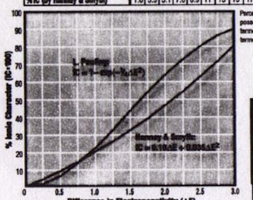
▼ Elementary Subatomic Particles

	Electron	Proton	Neutron	Photon	Neutrino
Symbol	e	p	n	γ	ν
Rest mass (kg)	$9.1093897(54) \times 10^{-31}$	$1.6726231(10) \times 10^{-27}$	$1.6749286(10) \times 10^{-27}$	0	≈0
Molar mass (kg/mol)	$5.48579903(13) \times 10^{-7}$	$1.007276470(12) \times 10^{-3}$	$1.008664904(14) \times 10^{-3}$	0	≈0
Particle-electron mass ratio	1	1836.152701(37)	1838.683662(40)	0	≈0
Particle-proton mass ratio	$5.44617013(11) \times 10^{-4}$	1	1.001378404(9)	0	≈0
Particle-neutron mass ratio	5.438673×10^{-4}	0.998624	1	0	≈0
Specific charge (C/kg)	$-1.75881962(53) \times 10^{+11}$	$9.5788309(29) \times 10^{+7}$	0	0	0
Radius (m)	$<1 \times 10^{-18}$	8×10^{-16}	8×10^{-16}	0	≈0
Spin quantum number	1/2	1/2	1/2	1	1/2
Compton wavelength (m)	$2.42631058(22) \times 10^{-12}$	$1.32141002(12) \times 10^{-15}$	$1.31959110(12) \times 10^{-5}$	–	–
Magnetic moment (J/T); μ	$928.47701(31) \times 10^{-26}$	$1.41060761(47) \times 10^{-26}$	$0.96623707(40) \times 10^{-26}$	0	0
In Bohr magnetons; μ/μ_B	1.001159652193(10)	$1.521032202(15) \times 10^{-3}$	$1.04187563(25) \times 10^{-3}$	0	0
In nuclear magnetons; μ/μ_N	1838.282000(37)	2.792847386(63)	1.91304275(45)	0	0

Elementary particles are the fundamental constituents of energy and matter. The positron (e^+) is a positive-energy particle which has the same mass as an ordinary electron. The antineutrino ($\bar{\nu}$) has similar properties as that of a neutrino (ν) except its spin is directed along its direction of motion, whereas the neutrino's spin is always opposite to the direction of motion. Negative beta decay is the transformation of a neutron into a proton, a beta particle (negative electron) and a antineutrino ($n \rightarrow p + e^- + \bar{\nu}$). Positive beta decay involves the transformation of a proton into a neutron, a positron and a neutrino ($p \rightarrow n + \beta^+ + \nu$). The magnetic moment (μ) of a particle can also be expressed as a dimensionless quantity by dividing it with either the Bohr magneton ($\mu_B = 9.2740154(31) \times 10^{-24}$ J/T) or the nuclear magneton ($\mu_N = 5.0507866(17) \times 10^{-27}$ J/T).

▼ % Ionic Character of a Single Chemical Bond

Difference in Electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
%IC (by L. Pauling)	0.2	1.0	2.2	3.9	6.1	8.6	12	15	18	22	26	30	34	39	43	47	51	56	59	63	67	70	73	76	79	82	84	86	88	89	91	92
%IC (by Hannay & Smyth)	1.6	3.3	5.1	7.0	8.9	11	13	15	17	20	22	24	27	29	32	35	37	40	43	46	49	52	55	59	62	65	69	72	76	80	83	87



Percent ionic character describes the nature of a bond. Bonds possessing 50% or greater ionic character are commonly termed ionic; bonds with less than 50% ionic character are termed covalent. Pauling's equation was modified by Hannay & Smyth in order to achieve better agreement between experimental and calculated values. Transition from ionic to covalent binding is usually accompanied by a reduction in electrical conductance, melting point and boiling point.

Elements

Group headings as printed: 1 IA IA; 2 IIA IIA; 3 IIIA IIIB; 4 IVA IVB; 5 VA VB; 6 VIA VIB; 7 VIIA VIIB; 8 VIIIA VIII; 9 VIIIA VIII; 10 VIIIA VIII; 11 IB IB; 12 IIB IIB; 13 IIIB IIIA; 14 IVB IVA; 15 VB VA; 16 VIB VIA; 17 VIIB VIIA; 18 VIII 0.

Atomic Number	Symbol	Name	Atomic Weight	Electronic Configuration
1	H	Hydrogen	1.00794	$1s^1$
2	He	Helium	4.002602	$1s^2$
3	Li	Lithium	6.941	[He]$2s^1$
4	Be	Beryllium	9.012182	[He]$2s^2$
5	B	Boron	10.811	[He]$2s^2p^1$
6	C	Carbon	12.011	[He]$2s^2p^2$
7	N	Nitrogen	14.00674	[He]$2s^2p^3$
8	O	Oxygen	15.9994	[He]$2s^2p^4$
9	F	Fluorine	18.9984032	[He]$2s^2p^5$
10	Ne	Neon	20.1797	[He]$2s^2p^6$
11	Na	Sodium	22.989768	[Ne]$3s^1$
12	Mg	Magnesium	24.3050	[Ne]$3s^2$
13	Al	Aluminum	26.981539	[Ne]$3s^2p^1$
14	Si	Silicon	28.0855	[Ne]$3s^2p^2$
15	P	Phosphorus	30.973762	[Ne]$3s^2p^3$
16	S	Sulfur	32.066	[Ne]$3s^2p^4$
17	Cl	Chlorine	35.4527	[Ne]$3s^2p^5$
18	Ar	Argon	39.948	[Ne]$3s^2p^6$
19	K	Potassium	39.0983	[Ar]$4s^1$
20	Ca	Calcium	40.078	[Ar]$4s^2$
21	Sc	Scandium	44.955910	[Ar]$3d^14s^2$
22	Ti	Titanium	47.88	[Ar]$3d^24s^2$
23	V	Vanadium	50.9415	[Ar]$3d^34s^2$
24	Cr	Chromium	51.9961	[Ar]$3d^54s^1$
25	Mn	Manganese	54.93805	[Ar]$3d^54s^2$
26	Fe	Iron	55.847	[Ar]$3d^64s^2$
27	Co	Cobalt	58.93320	[Ar]$3d^74s^2$
28	Ni	Nickel	58.6934	[Ar]$3d^84s^2$
29	Cu	Copper	63.546	[Ar]$3d^{10}4s^1$
30	Zn	Zinc	65.39	[Ar]$3d^{10}4s^2$
31	Ga	Gallium	69.723	[Ar]$3d^{10}4s^2p^1$
32	Ge	Germanium	72.61	[Ar]$3d^{10}4s^2p^2$
33	As	Arsenic	74.92159	[Ar]$3d^{10}4s^2p^3$
34	Se	Selenium	78.96	[Ar]$3d^{10}4s^2p^4$
35	Br	Bromine	79.904	[Ar]$3d^{10}4s^2p^5$
36	Kr	Krypton	83.80	[Ar]$3d^{10}4s^2p^6$
37	Rb	Rubidium	85.4678	[Kr]$5s^1$
38	Sr	Strontium	87.62	[Kr]$5s^2$
39	Y	Yttrium	88.90585	[Kr]$4d^15s^2$
40	Zr	Zirconium	91.224	[Kr]$4d^25s^2$
41	Nb	Niobium	92.90638	[Kr]$4d^45s^1$
42	Mo	Molybdenum	95.94	[Kr]$4d^55s^1$
43	Tc	Technetium	(97.9072)	[Kr]$4d^55s^2$
44	Ru	Ruthenium	101.07	[Kr]$4d^75s^1$
45	Rh	Rhodium	102.90550	[Kr]$4d^85s^1$
46	Pd	Palladium	106.42	[Kr]$4d^{10}$
47	Ag	Silver	107.8682	[Kr]$4d^{10}5s^1$
48	Cd	Cadmium	112.411	[Kr]$4d^{10}5s^2$
49	In	Indium	114.818	[Kr]$4d^{10}5s^2p^1$
50	Sn	Tin	118.710	[Kr]$4d^{10}5s^2p^2$
51	Sb	Antimony	121.757	[Kr]$4d^{10}5s^2p^3$
52	Te	Tellurium	127.60	[Kr]$4d^{10}5s^2p^4$
53	I	Iodine	126.90447	[Kr]$4d^{10}5s^2p^5$
54	Xe	Xenon	131.29	[Kr]$4d^{10}5s^2p^6$
55	Cs	Cesium	132.90543	[Xe]$6s^1$
56	Ba	Barium	137.327	[Xe]$6s^2$
57	La	Lanthanum	138.9055	[Xe]$5d^16s^2$
72	Hf	Hafnium	178.49	[Xe]$4f^{14}5d^26s^2$
73	Ta	Tantalum	180.9479	[Xe]$4f^{14}5d^36s^2$
74	W	Tungsten	183.84	[Xe]$4f^{14}5d^46s^2$
75	Re	Rhenium	186.207	[Xe]$4f^{14}5d^56s^2$
76	Os	Osmium	190.23	[Xe]$4f^{14}5d^66s^2$
77	Ir	Iridium	192.22	[Xe]$4f^{14}5d^76s^2$
78	Pt	Platinum	195.08	[Xe]$4f^{14}5d^96s^1$
79	Au	Gold	196.96654	[Xe]$4f^{14}5d^{10}6s^1$
80	Hg	Mercury	200.59	[Xe]$4f^{14}5d^{10}6s^2$
81	Tl	Thallium	204.3833	[Xe]$4f^{14}5d^{10}6s^2p^1$
82	Pb	Lead	207.2	[Xe]$4f^{14}5d^{10}6s^2p^2$
83	Bi	Bismuth	208.98037	[Xe]$4f^{14}5d^{10}6s^2p^3$
84	Po	Polonium	(208.9824)	[Xe]$4f^{14}5d^{10}6s^2p^4$
85	At	Astatine	(209.9871)	[Xe]$4f^{14}5d^{10}6s^2p^5$
86	Rn	Radon	(222.0176)	[Xe]$4f^{14}5d^{10}6s^2p^6$
87	Fr	Francium	(223.0197)	[Rn]$7s^1$
88	Ra	Radium	(226.0254)	[Rn]$7s^2$
89	Ac	Actinium	(227.0278)	[Rn]$6d^17s^2$
104	Unq	Unnilquadium	(261.11)	[Rn]$5f^{14}6d^27s^2$
105	Unp	Unnilpentium	(262.114)	[Rn]$5f^{14}6d^37s^2$
106	Unh	Unnilhexium	(263.118)	[Rn]$5f^{14}6d^47s^2$
107	Uns	Unnilseptium	(262.12)	[Rn]$5f^{14}6d^57s^2$
108	Uno	Unniloctium	(265)	[Rn]$5f^{14}6d^67s^2$
109	Une	Unnilennium	(266)	[Rn]$5f^{14}6d^77s^2$
110	Uun	Ununnilium	(272)	
58	Ce	Cerium	140.115	[Xe]$4f^15d^16s^2$
59	Pr	Praseodymium	140.90765	[Xe]$4f^36s^2$
60	Nd	Neodymium	144.24	[Xe]$4f^46s^2$
61	Pm	Promethium	(144.9127)	[Xe]$4f^56s^2$
62	Sm	Samarium	150.36	[Xe]$4f^66s^2$
63	Eu	Europium	151.965	[Xe]$4f^76s^2$
64	Gd	Gadolinium	157.25	[Xe]$4f^75d^16s^2$
65	Tb	Terbium	158.92534	[Xe]$4f^96s^2$
66	Dy	Dysprosium	162.50	[Xe]$4f^{10}6s^2$
67	Ho	Holmium	164.93032	[Xe]$4f^{11}6s^2$
68	Er	Erbium	167.26	[Xe]$4f^{12}6s^2$
69	Tm	Thulium	168.93421	[Xe]$4f^{13}6s^2$
70	Yb	Ytterbium	173.04	[Xe]$4f^{14}6s^2$
71	Lu	Lutetium	174.967	[Xe]$4f^{14}5d^16s^2$
90	Th	Thorium	232.0381	[Rn]$6d^27s^2$
91	Pa	Protactinium	231.03588	[Rn]$5f^26d^17s^2$
92	U	Uranium	238.0289	[Rn]$5f^36d^17s^2$
93	Np	Neptunium	(237.0482)	[Rn]$5f^46d^17s^2$
94	Pu	Plutonium	(244.0642)	[Rn]$5f^67s^2$
95	Am	Americium	(243.0614)	[Rn]$5f^77s^2$
96	Cm	Curium	(247.0703)	[Rn]$5f^76d^17s^2$
97	Bk	Berkelium	(247.0703)	[Rn]$5f^97s^2$
98	Cf	Californium	(251.0796)	[Rn]$5f^{10}7s^2$
99	Es	Einsteinium	(252.083)	[Rn]$5f^{11}7s^2$
100	Fm	Fermium	(257.0951)	[Rn]$5f^{12}7s^2$
101	Md	Mendelevium	(258.10)	[Rn]$5f^{13}7s^2$
102	No	Nobelium	(259.1009)	[Rn]$5f^{14}7s^2$
103	Lr	Lawrencium	(262.11)	[Rn]$5f^{14}6d^17s^2$

*indicates approximate values and/or inconsistent literature data.

The data for this reference guide were obtained from the latest scientific and government sources (IUPAC, CODATA, National Bureau of Standards, etc.). Estimated values and/or inconsistent data are marked with an asterisk (*).

1. Ratio of the average mass per atom of the element to 1/12 of the mass of an atom of ^{12}C. Round brackets indicate atomic weight of the most stable or best known isotope. 2. Number of protons in the nucleus of each atom of an element. 3. Number of charges an atom would have in a molecule (or an ionic compound) if electrons were transferred completely. 4. Names and symbols of elements 104-110 are those recommended by the International Union of Pure and Applied Chemistry (IUPAC)—alternative names have been proposed by other groups. 5. Distribution of electrons among the various atomic orbitals. 6. Two older group classifications systems still in use today rely on an A/B coding scheme to categorize periodic properties. Because of the potential for confusion between these two systems (i.e., VIIA in one scheme is equal to VIIB in the other), IUPAC recommends the use of an unambiguous 1-18 group classification system. 7. Melting point: temperature at which solid and liquid phases coexist in equilibrium. Boiling point: temperature at which the vapor pressure of a liquid is equal to the external atmospheric pressure. Unless otherwise stated values are at 1 atm; SP = sublimation point at 1 atm; TP = triple point. 8. Mass of the substance divided by its volume (g/cm³ at 20°C; for gases: g/L at 0°C, 1 atm). 9. Relative measure of the attraction of an atom in a chemical bond for the shared electrons. 10. Minimum energy to remove an electron from an isolated atom in its ground state (1eV = 96.487 kJ/mol).

Key

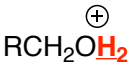
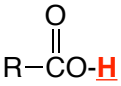
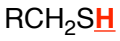
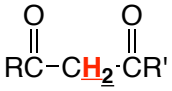
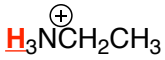
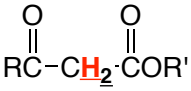
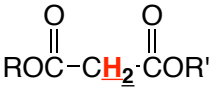
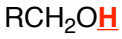
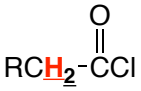
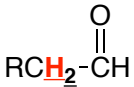
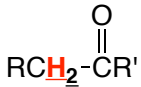
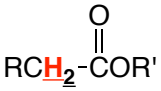
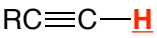
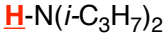
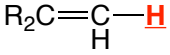
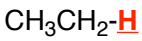
7 VIIA VIIB — 54.93805 — 25 — 1246 — 2061 — 2,3,4,6,7 — 7.47 — 1.55 — 7.435 — Mn — [Ar]$3d^54s^2$ — Manganese

- Atomic Weight[1] ( ) indicates most stable or best known isotope
- Melting Point[7], °C
- Boiling Point[7], °C
- Density[8], g/cm³ (gases: g/L at 0°C, 1 atm)
- Electronegativity[9]
- First Ionization Potential[10], eV
- Group Classifications[6]
- Atomic Number[2]
- Oxidation States[3] bold indicates most stable state
- Symbol[4] black = solid, red = gas, blue = liquid, outline = synthetically prepared
- Electronic[5] Configuration
- Name[4]

● Lanthanides (58–71)
●● Actinides (90–103)

PAPERTECH

Editors: T. K. Varga, M.A.Sc. & C. Bello, M.A.Sc.
Product No. LCH-04F **ISBN** 1-55080-073-6

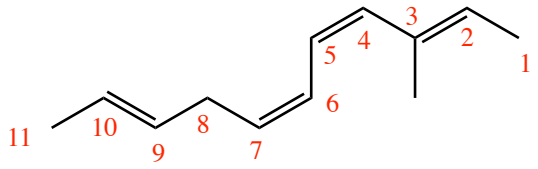
Compound		pK_a
Hydrochloric acid		-7
Protonated alcohol		-2
Hydronium ion		-1.7
Carboxylic acids		3-5
Thiols		8-9
Ammonium ion		9.2
β-Dicarbonyls		10
Primary ammonium		10.5
β-Ketoesters		11
β-Diesters		13
Water		15.7
Alcohols		15-19
Acid chlorides		16
Aldehydes		18-20
Ketones		18-20
Esters		23-25
Terminal alkynes		25
LDA		40
Terminal alkenes		44
Alkanes		51

Signature_____ Pg 1 _____(23)

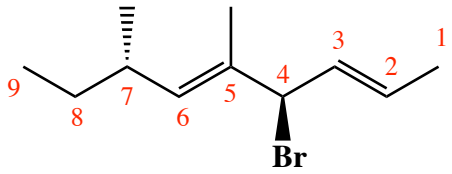
1. (5 pts) What is the most important question in organic chemistry?

Where are the electrons?

2. (12 pts) Write an acceptable IUPAC name for the following two molecules. Where appropriate, use E and Z or R and S.



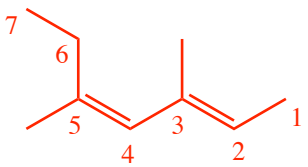
(2*E*,4*Z*,6*Z*,9*E*)-3-methyl-2,4,6,9-undecatetraene



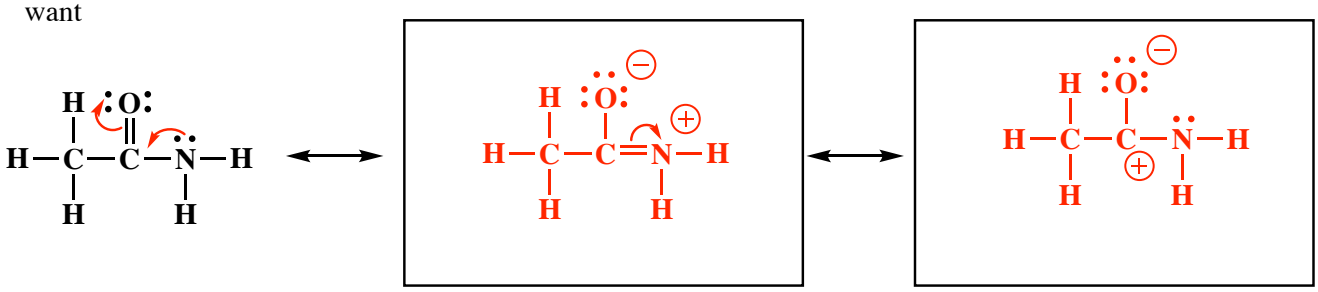
(2*E*,4*R*,5*E*,7*S*)-4-bromo-5,7-dimethyl-2,5-nonadiene

3. (6 pts) Draw the structure that corresponds to the following name:

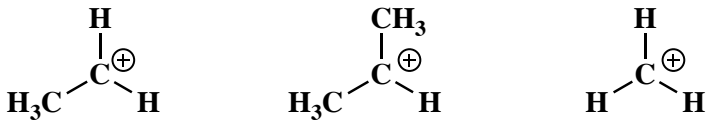
(2*E*,4*Z*)-3,5-dimethyl-2,4-heptadiene



4. (10 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew. There is no need to draw any circles around any of these contributing strucures. You might want to read these directions again to make sure you know what we want



5. (2 pts each) Consider the three structures below, then fill in each space with the letter, word or number that best completes each of the following sentences.



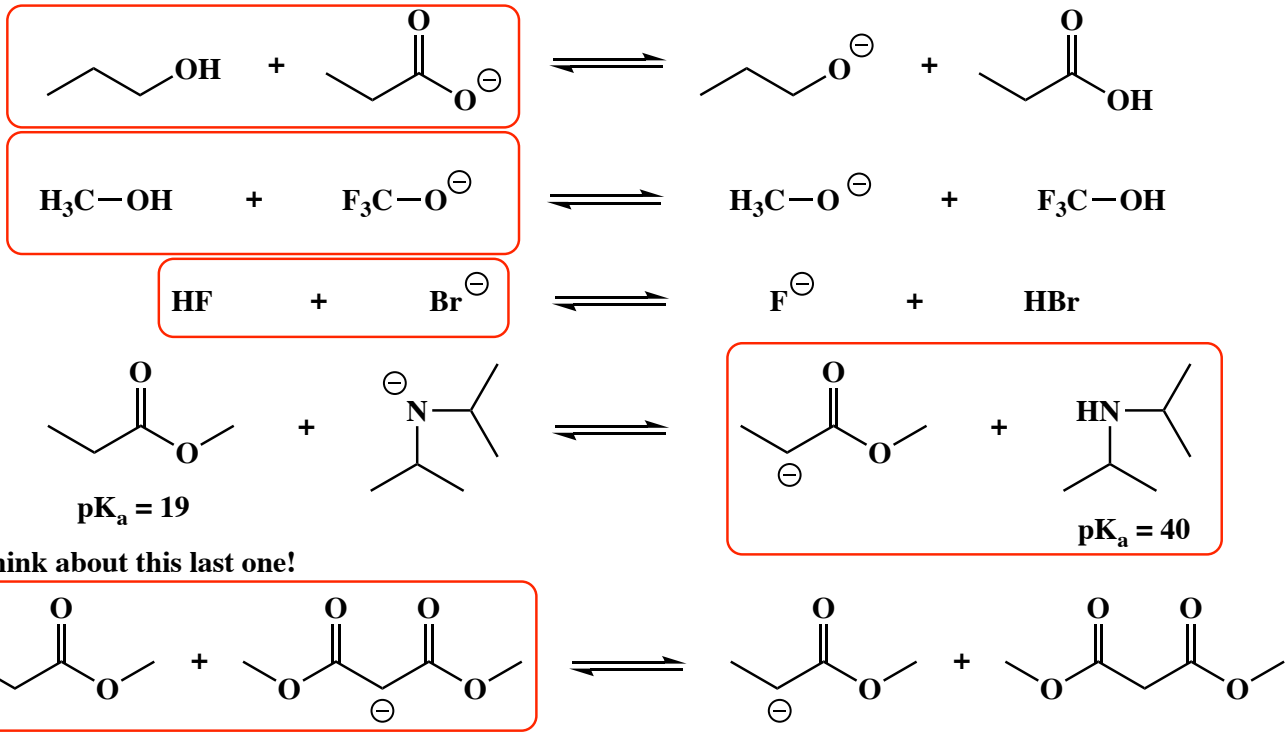
A **B** **C**

The letter that corresponds to the most stable of the three carbocations shown above is ___B___ **.**

The most stable carbocation is the one that is ___lowest___ **(lowest or highest) in energy. The hybridizaton state of the positively-charged carbon atom in the most stable carbocation is** ___sp^2___ **. For the most stable carbocation, there are** ___6___ **(a number) total C-H sigma bonds that overlap with the empty** ___2p___ **orbital of the postitively-charged C atom, providing stabilization via an interaction called** ___hyperconjugation___ **.**

The most stable carbocation is stabilized by a second effect called the ___inductive___ **effect. For this second interaction on the most stable carbocation, electron density is drawn to the positively-charged carbon atom from** ___2___ **(a number) other carbon atom(s). This happens because of the fact that the positively-charged carbon atom is** ___more___ **(more or less) electronegative than a carbon atom with no full positive charge. The most stable carbocation above is referred to as a** ___secondary___ **(methyl, primary, secondary or tertiary) carbocation.**

6. (10 pts) For each acid-base reaction, **circle the side of the equation that predominates at equilibrium.** **In each case identify the stronger and weaker acids by comparing relative stabilities of the anions which are the conjugate bases of the two acids. Equilibrium favors formation of the weaker acid. You will notice this means you circled the side with the more stable anion.**



Think about this last one!

7. (2 or 4 pts each) For the following, **circle the capitalized word** that best completes the statement.

In general, it is best to think of alkenes as NUCLEOPHILES or ELECTROPHILES that react with NUCLEOPHILES or ELECTROPHILES such as Br_2.

In general, NUCLEOPHILES or ELECTROPHILES serve as electron sources and NUCLEOPHILES or ELECTROPHILES serve as electron sinks for the arrows used to indicate bond-making steps in reactions.

A pi bond or lone pair will serve as an ELECTRON SOURCE or ELECTRON SINK for an arrow that indicates the making of a new bond.

An atom that can accommodate a new bond can serve as an ELECTRON SOURCE or ELECTRON SINK for an arrow that indicates the making of a new bond.

A reaction that occurs slower generally has a LOWER or HIGHER activation energy.

A reaction that has a strong thermodynamic driving force (a strong motive) is FAVORABLE or UNFAVORABLE as written.

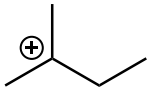
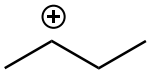
A reaction will have a strong motive (thermodynamic driving force) if the bonds made are STRONGER or WEAKER than the bonds that are broken.

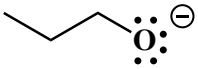
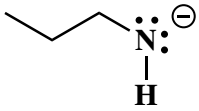
8. (2 pts each) Write the mechanistic element (of the four) that is appropriate when you see the following species in a mechanism:

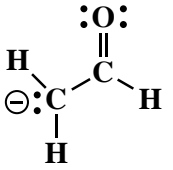
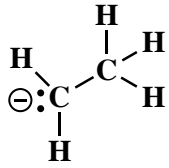
A nucleophile and an electrophile are present	**Make a bond between a nucleophile and an electrophile**
The carbon containing species is a weak base and there is a strong acid present	**Add a proton**
The carbon containing species is a strong acid and a base is present	**Take a proton away**
The carbon containing species can fragment to make water and a tertiary carbocation	**Break a bond to give stable molecules or ions**

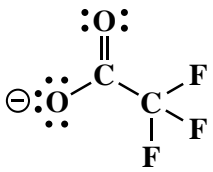
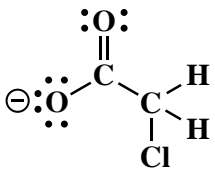
9. (2 pts each no partial credit) The following statements are true. Choose from among the following five possibilities and in the space provided, write the letter of the one *or more* phenomena that best explain the true statement.

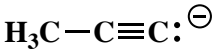
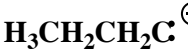
A. The inductive effect **B. Hyperconjugation** **C. Resonance delocalization of a charged species**
D. Greater s character of the orbital containing an electron pair on a negatively-charged atom **E. The negative charge is on a more electronegative element**

 **is lower in energy than**  **because of:** **A, B**

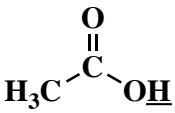
 **is lower in energy than**  **because of:** **E**

 **is lower in energy than**  **because of:** **C (A is OK)**

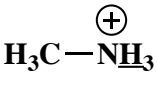
 **is lower in energy than**  **because of:** **A**

 **is lower in energy than**  **because of:** **D**

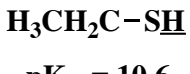
10. (12 pts) **Complete the following two structures by adding appropriate numbers of lone pair electrons, H atoms, and formal charges to the atoms in the boxes.** You must adjust your answers to indicate the predominant species at each indicated pH value. (You do not have to add anything such as H atoms to atoms not drawn in the boxes.) This problem is testing your understanding of the relationship of protonation state to pH to pKa values for certain functional groups we have discussed. **Next, in the space provided, write the overall charge on each structure at the indicated pH. For your reference, here are the relevant pK_a values:**



pK_a = 4.76

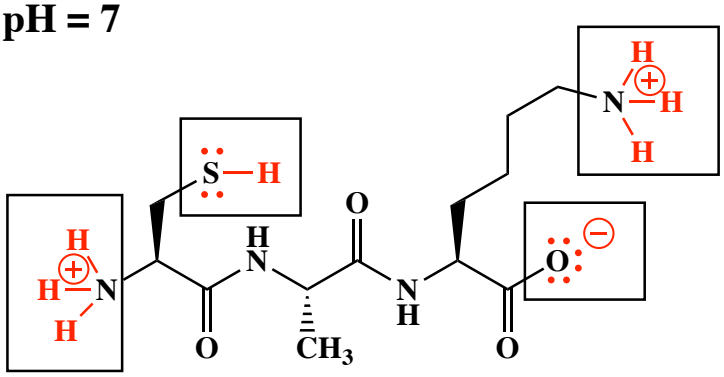


pK_a = 10.64



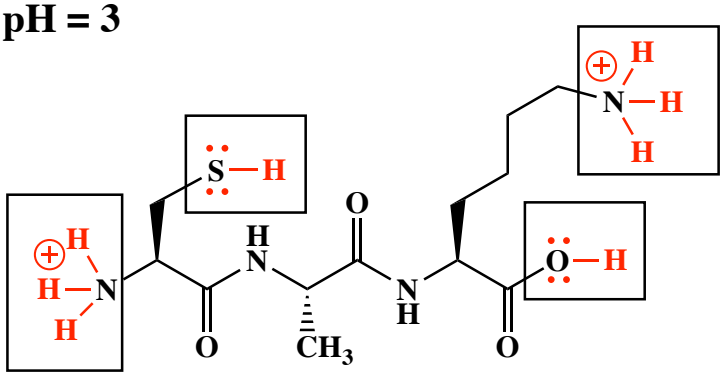
pK_a = 10.6

pH = 7



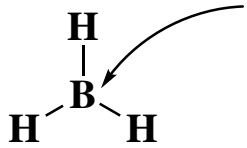
Total charge on molecule: +1

pH = 3



Total charge on molecule: +2

11. (2 pts each) **Complete** the following set of questions related to derivatives of boron.



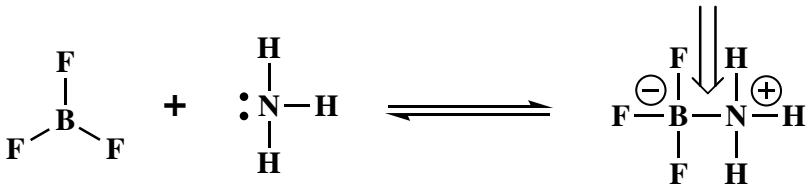
What is the hybridization state of the B atom? ***sp²***

The BH_3 molecule has ___**6**___ valence electrons around the B atom.

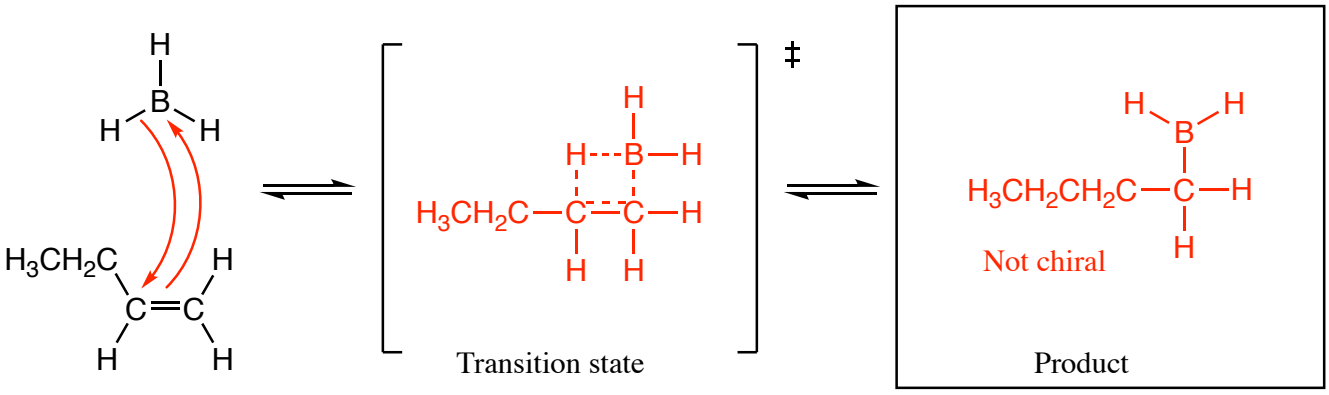
The BH_3 molecule is best considered a Lewis ___**acid**___ .

In the BH_3 molecule, there is an empty ___**2p**___ orbital on the B atom.

Related molecules such as BF_3 react with ammonia to create a special type of bond known as a ___**coordinate covalent or dative**___ bond that is illustrated in the following equation and indicated by the arrow:

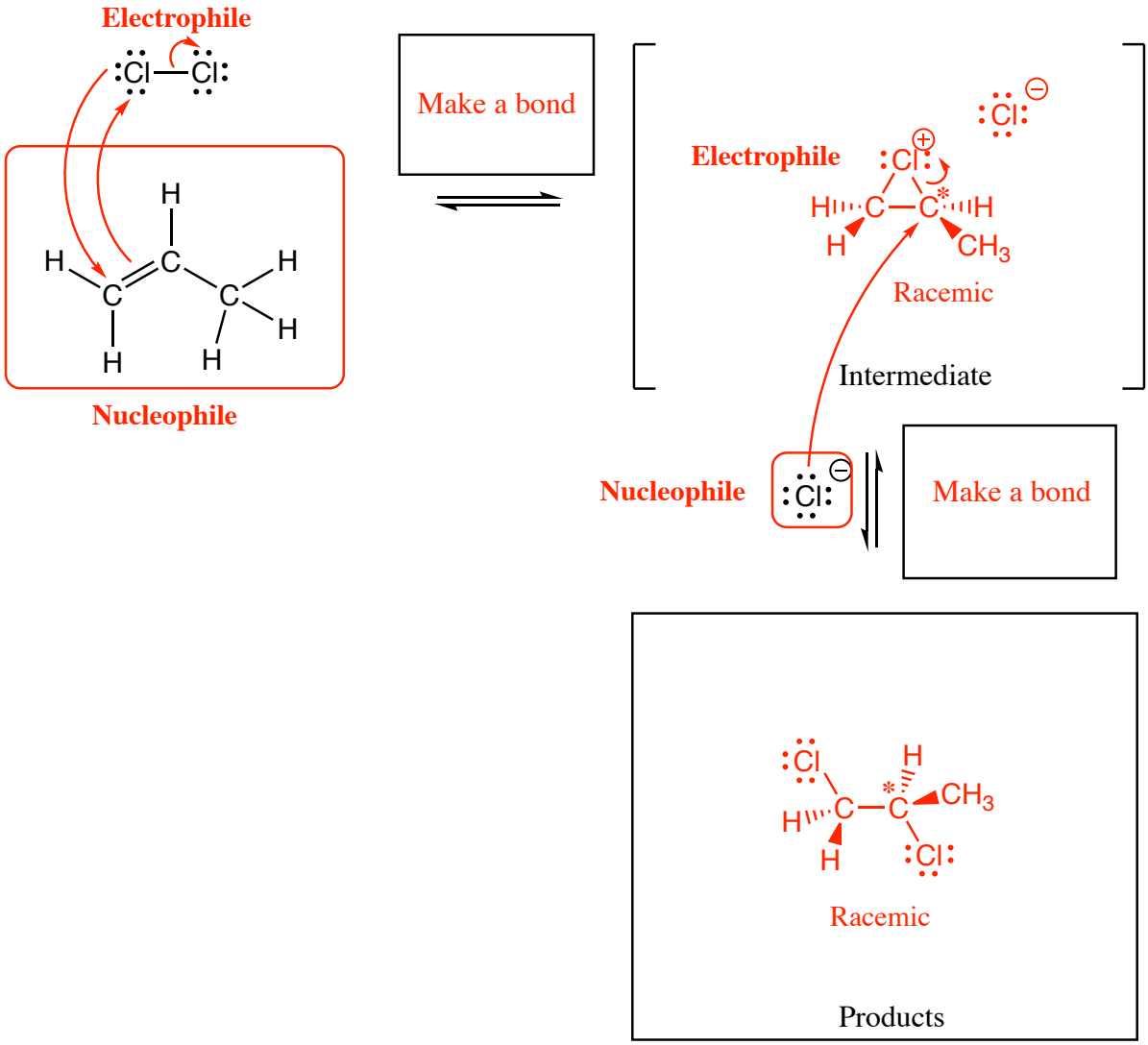


12. (10 pts) Complete the following mechanism for the first step of the hydroboration reaction. Use arrows to indicate the movement of all electrons and be sure to show all electron pairs and formal charges. For this one, we are asking you to draw a transition state. Used dotted lines to indicated any bonds that are being made or broken in the transition state. Indicate any chiral centers with an asterisk (*) and write 'racemic" if appropriate. You only need to draw one stereoisomer of any chiral species. **Note that you should only draw arrows on the structure to the left, not the transition state. NOTICE THE QUESTION AT THE END.**



(4 pts) Look as the energy diagrams on page 9. Write the letter of the one that best describes the mechanism of this reaction. ***A***

13. (12 pts) Complete the mechanism for the following alkene halogenation reaction. **Be sure to show arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. In the boxes provided, write which of the 4 mechanistic elements describes each step (make a bond, break a bond, etc.). Be sure to notice the questions at the end.**

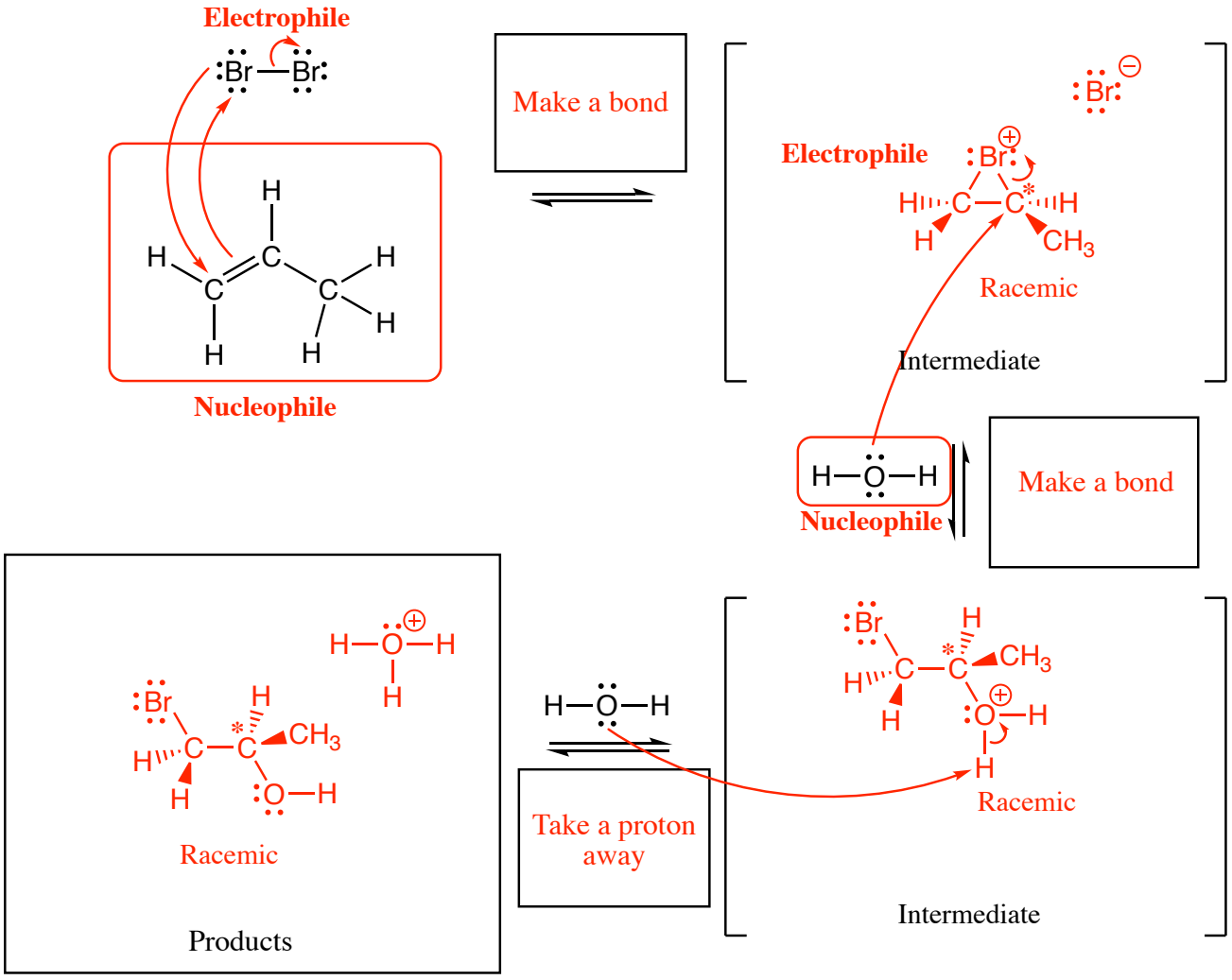


(4 pts) **For any step** in the mechanism on this page that involves a nucleophile reacting with an electrophile to make a bond, **draw a circle around the nucleophile**

(2 pts) How many total stereoisomers are created as the final products? **2**

(4 pts) Look as the energy diagrams on page 9. Write the letter of the one that best describes this reaction. **B**

14. (19 pts) Complete the mechanism for the following alkene hydrohalogenation reaction. **Be sure to show arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **YOU ONLY NEED TO DRAW ONE STEREOISOMER OF A CHIRAL INTERMEDIATE OR PRODUCT (using wedges and dashes as appropriate) IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR PRODUCT, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. In the boxes provided, write which of the 4 mechanistic elements describes each step (make a bond, break a bond, etc.). Be sure to notice the questions at the end.**



(4 pts) **For any step** in the mechanism on this page that involves a nucleophile reacting with an electrophile to make a bond, **draw a circle around the nucleophile**

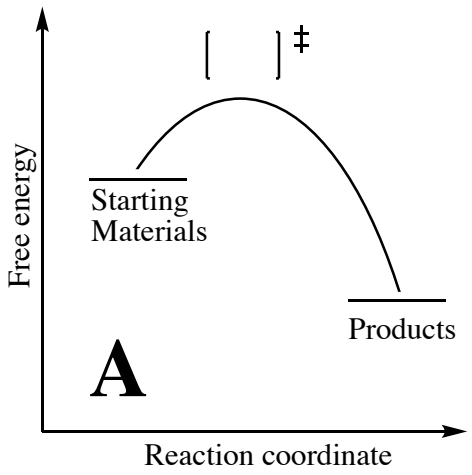
(2 pts) **How many total stereoisomers** are created as the final **products**? **2**

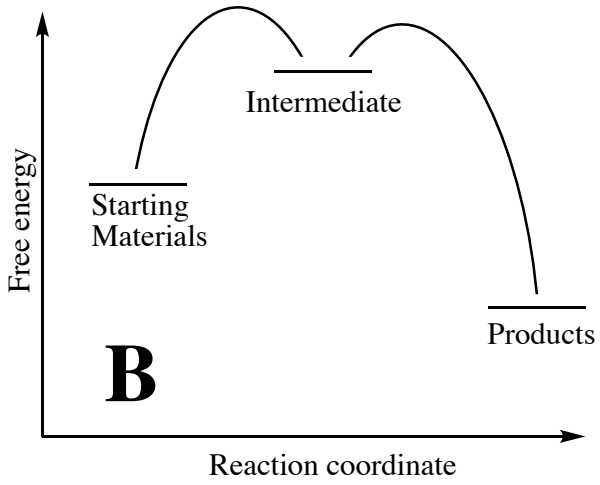
(4 pts) **Look as the energy diagrams on page 9. Write the letter of the one that best describes this reaction.** **C**

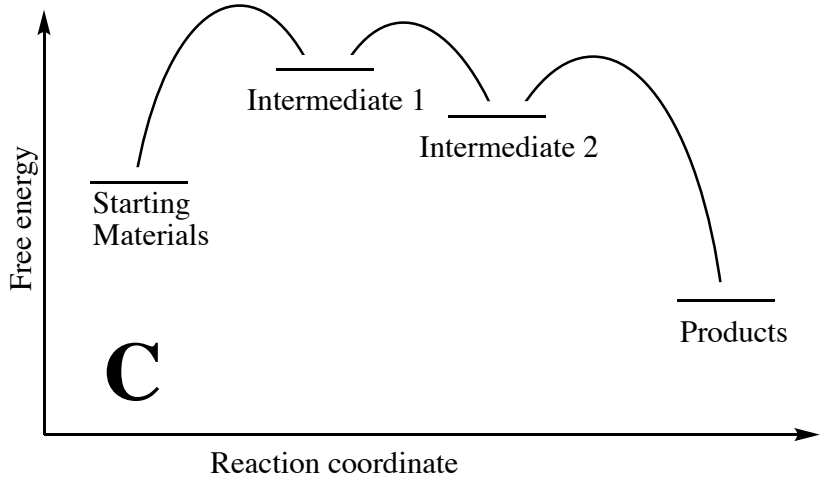
(2 pts) Think about this! As the reaction progresses, does the pH get **higher, lower, or stay the same?**

it gets lower (acid is created)

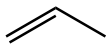
These energy diagrams refer to the mechanisms your completed in problems 12-14 on pages 6-8.



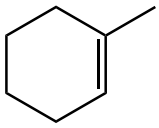
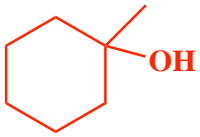


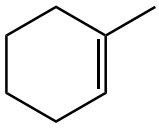
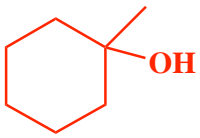


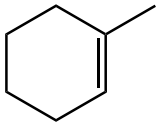
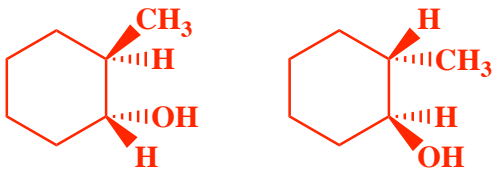
15. (3 or 5 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov products)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry as appropriate**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

A.  $\xrightarrow{Br_2}$ 

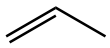
Racemic

B.  $\xrightarrow[H_2SO_4\ (catalytic\ amount)]{H_2O}$ 

C.  $\xrightarrow[2.\ NaBH_4]{1.\ Hg(OAc)_2\ /\ H_2O}$ 

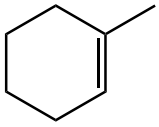
D.  $\xrightarrow[2.\ H_2O_2\ /\ NaOH]{1.\ BH_3}$ 

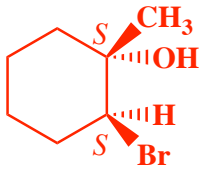
Racemic

E.  $\xrightarrow[H_2O]{Br_2}$ 

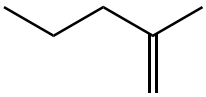
Racemic

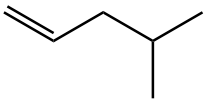
15. (3 or 5 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov products)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry when appropriate**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

F.  $\xrightarrow[H_2O]{Br_2}$

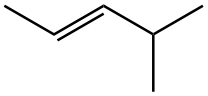


Racemic

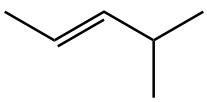
G.  $\xrightarrow{HCl}$

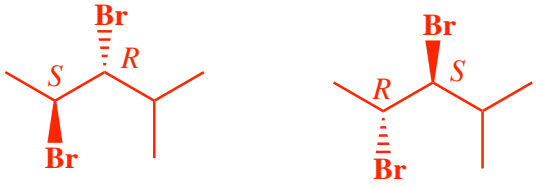
H.  $\xrightarrow{HI}$

Racemic

I.  $\xrightarrow{HCl}$

Assume rearrangement and draw the rearranged product only

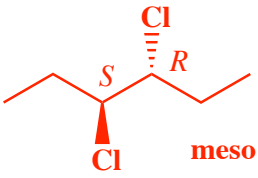
J.  $\xrightarrow{Br_2}$



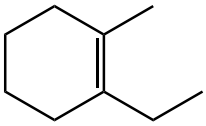
Racemic

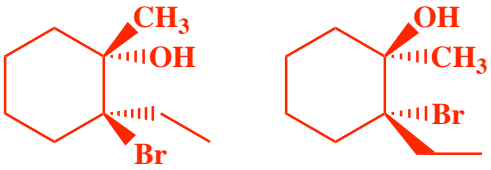
15. (5 or 10 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov products)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry as appropriate**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

K.  $\xrightarrow{Cl_2}$

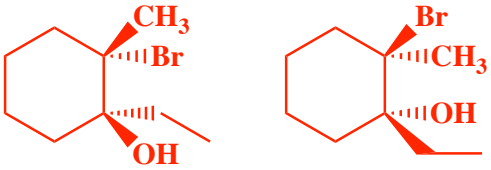


meso

L  $\xrightarrow[H_2O]{Br_2}$

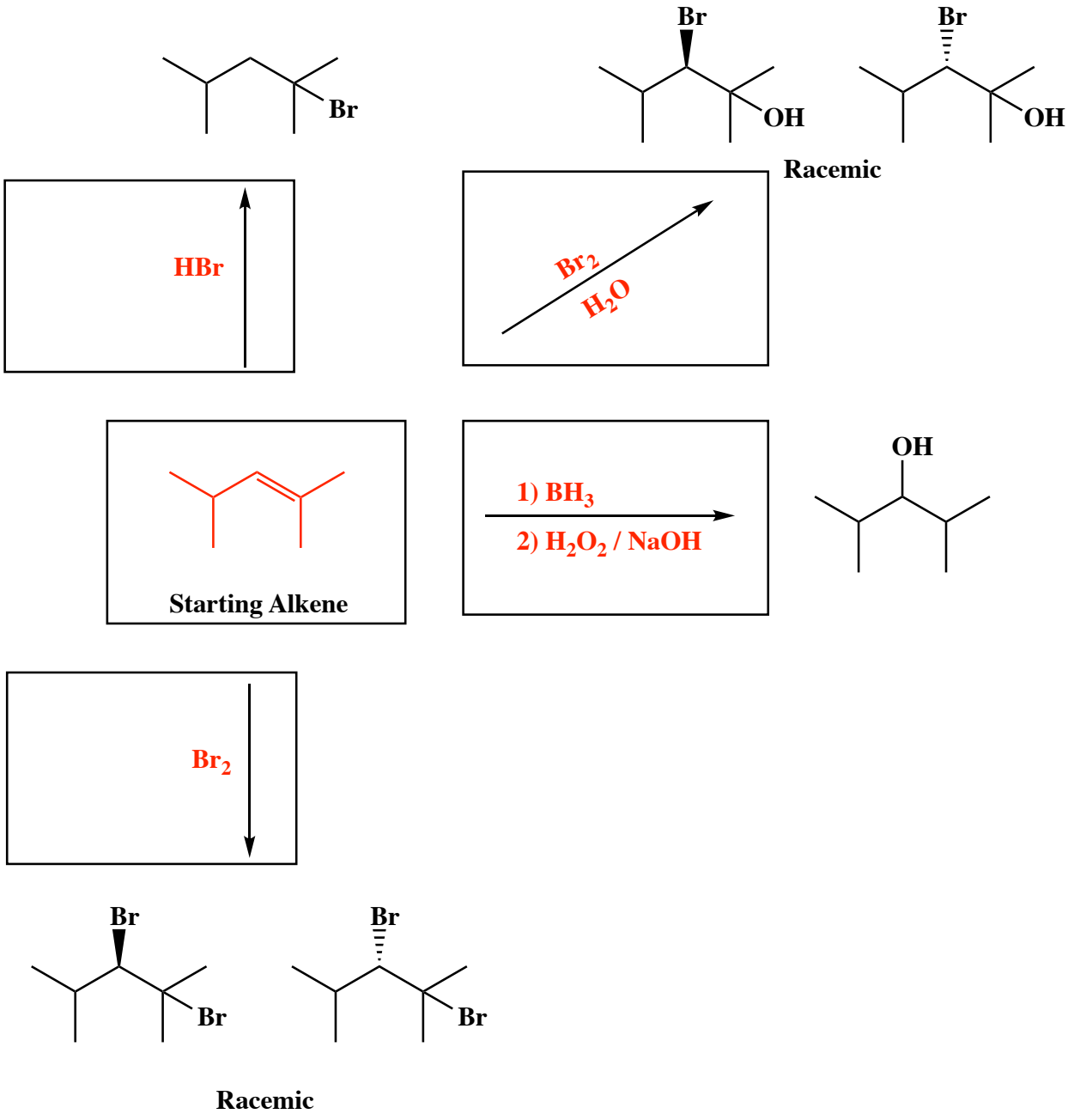


Racemic

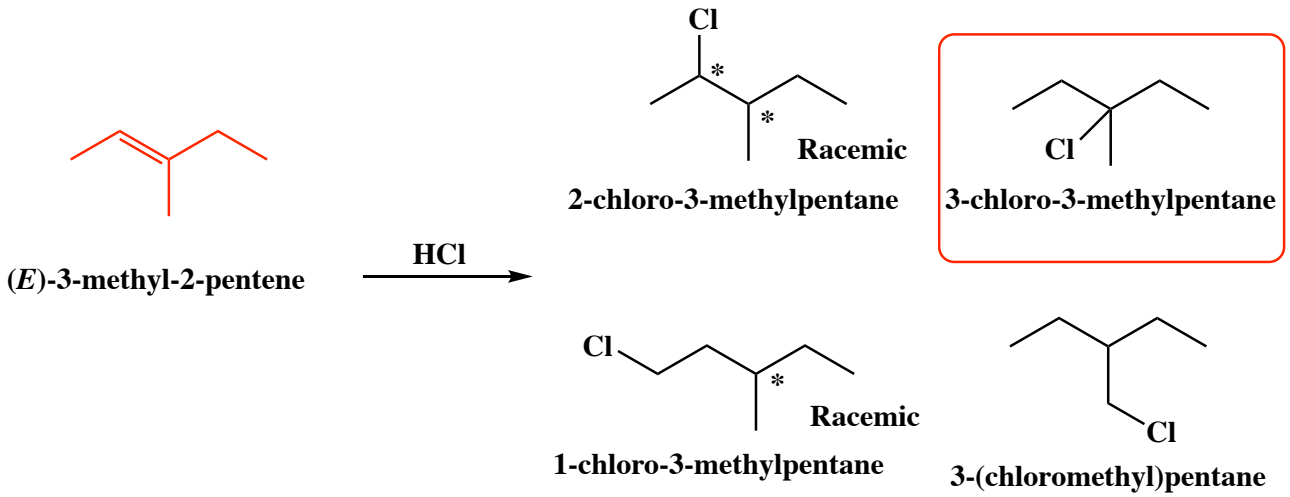


Racemic

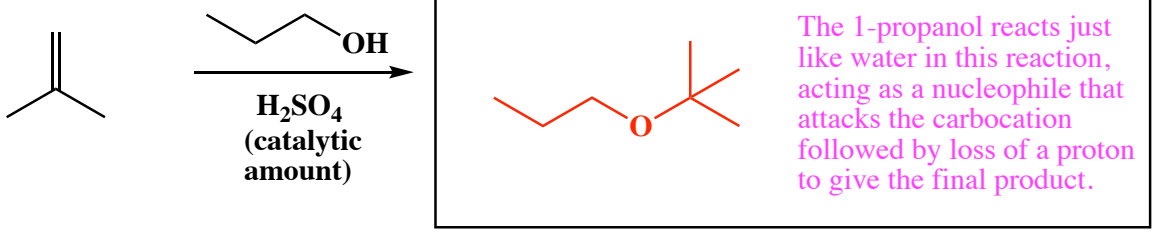
16. (16 pts total) Organic chemistry is a very creative science because there are so many different reactions known that often we are only limited by our imaginations. For example, the same starting alkene can be converted to the different products listed. **Deduce the identity of the starting alkene, and write its structure in the box labeled "Starting Alkene". Fill in the boxes containing arrows with the reagents required to produce the given products.**



17. (5 pts) The MCAT and other standard exams are famous for using IUPAC names instead of structures. From the following list, **circle the product of the following reaction.** To make this simpler, we have not used wedges and dashes, but simply designated chiral centers with an asterisk. (Note you are **NOT** allowed to write products in this format on pages 10-12 of this exam, you must use wedges and dashes on those!)



18. (8 pts total) Here is an "apply what you know" question. The reactions we teach in this class are representative examples of entire classes of reactions. Alkenes react with a variety of reagents that are similar to the ones we have discusseed. You have not seen the following two reactions, but use your growing chemical intuition to predict the products for the reactions shown. My only hint is for you to not overthink this, but rely on your understanding of mechanisms to make educated guesses. **The products should be drawn in the same format as for pages 10-12 of this exam.**



Save this one until last! I have given you the products, you need to draw the starting material