NAME (Print): ______________________________

SIGNATURE: ______________________________

Chemistry 320M/328M
Dr. Brent Iverson
2nd Midterm
October 25, 2012

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 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.

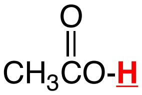
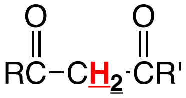
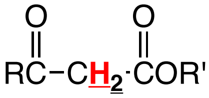
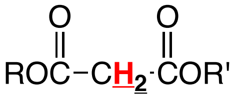
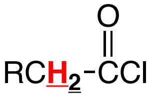
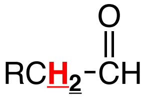
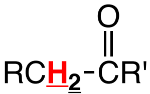
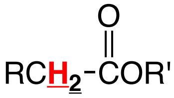
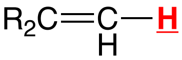
FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENCTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!

Honor Code

The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.

(Your signature)

Page	Points	
1		**(15)**
2		**(24)**
3		**(22)**
4		**(28)**
5		**(16)**
6		**(12)**
7		**(22)**
8		**(25)**
9		**(11)**
10		**(14)**
11		**(13)**
12		**(18)**
13		**(8)**
14		**(12)**
Total		**(240)**

Compound		pK_a
Hydrochloric acid	$\underline{H}\text{-}Cl$	-7
Protonated alcohol	$RCH_2\overset{\oplus}{O}\underline{H_2}$	-2
Hydronium ion	$\underline{H}_3O^{\oplus}$	-1.7
Acetic acid	 $CH_3\overset{O}{\overset{\|}{C}}O\text{-}\underline{H}$	4.8
Ammonium ion	$\underline{H}_4N^{\oplus}$	9.2
β-Dicarbonyls	 $R\overset{O}{\overset{\|}{C}}{-}C\underline{H_2}{\cdot}\overset{O}{\overset{\|}{C}}R'$	10
Ethyl ammonium ion	$\underline{H}_3\overset{\oplus}{N}{-}CH_2CH_3$	10.8
β-Ketoesters	 $R\overset{O}{\overset{\|}{C}}{-}C\underline{H_2}{\cdot}\overset{O}{\overset{\|}{C}}OR'$	11
β-Diesters	 $RO\overset{O}{\overset{\|}{C}}{-}C\underline{H_2}{\cdot}\overset{O}{\overset{\|}{C}}OR'$	13
Water	$HO\underline{H}$	15.7
Alcohols	$RCH_2O\underline{H}$	15-19
Acid chlorides	 $RC\underline{H_2}\text{-}\overset{O}{\overset{\|}{C}}Cl$	16
Aldehydes	 $RC\underline{H_2}\text{-}\overset{O}{\overset{\|}{C}}H$	18-20
Ketones	 $RC\underline{H_2}\text{-}\overset{O}{\overset{\|}{C}}R'$	18-20
Esters	 $RC\underline{H_2}\text{-}\overset{O}{\overset{\|}{C}}OR'$	23-25
Terminal alkynes	$RC{\equiv}C{-}\underline{H}$	25
LDA	$\underline{H}\text{-}N(i\text{-}C_3H_7)_2$	40
Terminal alkenes	 $R_2C{=}\underset{H}{C}{-}\underline{H}$	44
Alkanes	$CH_3CH_2\text{-}\underline{H}$	51

PERIODIC TABLE OF THE ELEMENTS

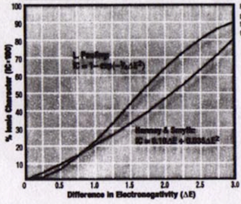
▼ Elementary Subatomic Particles

	Electron	Proton	Neutron	Photon	Neutrino
Symbol	e	p	n	γ	ν
Rest mass (kg)	9.1093897(54) x 10^{-31}	1.6726231(10) x 10^{-27}	1.6749286(10) x 10^{-27}	0	≈0
Molar mass (kg/mol)	5.48579903(13) x 10^{-7}	1.007276470(12) x 10^{-3}	1.008664904(14) x 10^{-3}	0	≈0
Particle-electron mass ratio	1	1836.152701(37)	1838.683662(40)	0	≈0
Particle-proton mass ratio	5.44617013(11) x 10^{-4}	1	1.001378404(9)	0	≈0
Particle-neutron mass ratio	5.438673x10^{-4}	0.998624	1	0	≈0
Specific charge (C/kg)	−1.75881962(53) x 10^{+11}	9.5788309(29) x 10^{+7}	0	0	0
Radius (m)	<1 x 10^{-18}	8 x 10^{-16}	8 x 10^{-16}	0	≈0
Spin quantum number	1/2	1/2	1/2	1	1/2
Compton wavelength (m)	2.42631058(22) x 10^{-12}	1.32141002(12) x 10^{-15}	1.31959110(12) x 10^{-15}	–	–
Magnetic moment (J/T); μ	928.47701(31) x 10^{-26}	1.41060761(47) x 10^{-26}	0.96623707(40) x 10^{-26}	0	0
In Bohr magnetons; μ/μ_B	1.001159652193(10)	1.521032202(15) x 10^{-3}	1.04187563(25) x 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 ($\mu$) of a particle can also be expressed as a dimensionless quantity by dividing it with either the Bohr magneton (μ_B = 9.2740154(31) x 10^{-24} J/T) or the nuclear magneton (μ_N = 5.0507866(17) x 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 Hanney & 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 Hanney & 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.

Atomic Number	Symbol	Name	Group Classifications	Atomic Weight	Melting Point, °C	Boiling Point, °C	Density	Electronegativity	First Ionization Potential, eV	Oxidation States	Electronic Configuration
1	H	Hydrogen	1 IA IA	1.00794	−259.34	−252.87	0.0899	2.20	13.598	1	$1s^1$
2	He	Helium	18 VIII 0	4.002602	−272.2 $^{26 atm}$	−268.93	0.1785	–	24.587		$1s^2$
3	Li	Lithium	1 IA IA	6.941	180.5	1342	0.534	0.98	5.392	1	[He]$2s^1$
4	Be	Beryllium	2 IIA IIA	9.012182	1287	2471	1.8477	1.57	9.322	2	[He]$2s^2$
5	B	Boron	13 IIIB IIIA	10.811	2075	4000	2.34	2.04	8.298	3	[He]$2s^2p^1$
6	C	Carbon	14 IVB IVA	12.011	4492*	3825*	2.25	2.55	11.260	2,±4	[He]$2s^2p^2$
7	N	Nitrogen	15 VB VA	14.00674	−210.00	−195.79	1.25046	3.04	14.534	2,±3,4,5	[He]$2s^2p^3$
8	O	Oxygen	16 VIB VIA	15.9994	−218.79	−182.95	1.429	3.44	13.618	−2	[He]$2s^2p^4$
9	F	Fluorine	17 VIIB VIIA	18.9984032	−219.62	−188.12	1.69	3.98	17.422	−1	[He]$2s^2p^5$
10	Ne	Neon	18 VIII 0	20.1797	−248.59	−246.08	0.9002	–	21.564		[He]$2s^2p^6$
11	Na	Sodium	1 IA IA	22.989768	97.72	883	0.97	0.93	5.139	1	[Ne]$3s^1$
12	Mg	Magnesium	2 IIA IIA	24.3050	650	1090	1.74	1.31	7.646	2	[Ne]$3s^2$
13	Al	Aluminum	13 IIIB IIIA	26.981539	660.32	2519	2.702	1.61	5.986	3	[Ne]$3s^2p^1$
14	Si	Silicon	14 IVB IVA	28.0855	1414	3265	2.33	1.90	8.151	4	[Ne]$3s^2p^2$
15	P	Phosphorus	15 VB VA	30.973762	44.15	277	1.82	2.19	10.486	±3,4,5	[Ne]$3s^2p^3$
16	S	Sulfur	16 VIB VIA	32.066	115.21	444.60	2.07	2.58	10.360	±2,4,6	[Ne]$3s^2p^4$
17	Cl	Chlorine	17 VIIB VIIA	35.4527	−101.5	−34.04	3.214	3.16	12.967	±1,3,5,7	[Ne]$3s^2p^5$
18	Ar	Argon	18 VIII 0	39.948	−189.35	−185.85	1.784	–	15.759		[Ne]$3s^2p^6$
19	K	Potassium	1 IA IA	39.0983	63.38	759	0.86	0.82	4.341	1	[Ar]$4s^1$
20	Ca	Calcium	2 IIA IIA	40.078	842	1484	1.54	1.00	6.113	2	[Ar]$4s^2$
21	Sc	Scandium	3 IIIA IIIB	44.955910	1541	2830	2.989	1.36	6.54	3	[Ar]$3d^14s^2$
22	Ti	Titanium	4 IVA IVB	47.88	1668	3287	4.5	1.54	6.82	3,4	[Ar]$3d^24s^2$
23	V	Vanadium	5 VA VB	50.9415	1910	3407	5.96	1.63	6.74	2,3,4,5	[Ar]$3d^34s^2$
24	Cr	Chromium	6 VIA VIB	51.9961	1907	2671	7.20	1.66	6.766	2,3,6	[Ar]$3d^54s^1$
25	Mn	Manganese	7 VIIA VIIB	54.93805	1246	2061	7.47	1.55	7.435	2,3,4,6,7	[Ar]$3d^54s^2$
26	Fe	Iron	8 VIIIA VIII	55.847	1538	2861	7.86	1.83	7.870	2,3	[Ar]$3d^64s^2$
27	Co	Cobalt	9 VIIIA VIII	58.93320	1495	2927	8.92	1.88	7.86	2,3	[Ar]$3d^74s^2$
28	Ni	Nickel	10 VIIIA VIII	58.6934	1455	2913	8.90	1.91	7.635	2,3	[Ar]$3d^84s^2$
29	Cu	Copper	11 IB IB	63.546	1084.62	2562	8.94	1.90	7.726	1,2	[Ar]$3d^{10}4s^1$
30	Zn	Zinc	12 IIB IIB	65.39	419.53	907	7.14 $^{25°C}$	1.65	9.394	2	[Ar]$3d^{10}4s^2$
31	Ga	Gallium	13 IIIB IIIA	69.723	29.76	2204	6.095	1.81	5.999	3	[Ar]$3d^{10}4s^2p^1$
32	Ge	Germanium	14 IVB IVA	72.61	938.25	2833	5.35	2.01	7.899	4	[Ar]$3d^{10}4s^2p^2$
33	As	Arsenic	15 VB VA	74.92159	817*	614*	5.727 $^{25°C}$	2.18	9.81	±3,5	[Ar]$3d^{10}4s^2p^3$
34	Se	Selenium	16 VIB VIA	78.96	221	685	4.81	2.55	9.752	−2,4,6	[Ar]$3d^{10}4s^2p^4$
35	Br	Bromine	17 VIIB VIIA	79.904	−7.2	58.8	3.119	2.96	11.814	±1,5	[Ar]$3d^{10}4s^2p^5$
36	Kr	Krypton	18 VIII 0	83.80	−157.36	−153.22	3.74	–	13.999		[Ar]$3d^{10}4s^2p^6$
37	Rb	Rubidium	1 IA IA	85.4678	39.31	688	1.532	0.82	4.177	1	[Kr]$5s^1$
38	Sr	Strontium	2 IIA IIA	87.62	777	1382	2.6	0.95	5.695	2	[Kr]$5s^2$
39	Y	Yttrium	3 IIIA IIIB	88.90585	1526	3336	4.469	1.22	6.38	3	[Kr]$4d^15s^2$
40	Zr	Zirconium	4 IVA IVB	91.224	1855	4409	6.49	1.33	6.84	4	[Kr]$4d^25s^2$
41	Nb	Niobium	5 VA VB	92.90638	2477	4744	8.57	1.6	6.9	3,5	[Kr]$4d^45s^1$
42	Mo	Molybdenum	6 VIA VIB	95.94	2623	4639	10.2	2.16	7.099	2,3,4,5,6	[Kr]$4d^55s^1$
43	Tc	Technetium	7 VIIA VIIB	(97.9072)	2157	4265	11.5	1.9	7.28	7	[Kr]$4d^55s^2$
44	Ru	Ruthenium	8 VIIIA VIII	101.07	2334	4150	12.3	2.2	7.37	2,3,4,6,8	[Kr]$4d^75s^1$
45	Rh	Rhodium	9 VIIIA VIII	102.90550	1964	3695	12.4	2.28	7.46	2,3,4	[Kr]$4d^85s^1$
46	Pd	Palladium	10 VIIIA VIII	106.42	1554.9	2963	12.02	2.20	8.34	2,4	[Kr]$4d^{10}$
47	Ag	Silver	11 IB IB	107.8682	961.78	2162	10.5	1.93	7.576	1	[Kr]$4d^{10}5s^1$
48	Cd	Cadmium	12 IIB IIB	112.411	321.07	767	8.642	1.69	8.993	2	[Kr]$4d^{10}5s^2$
49	In	Indium	13 IIIB IIIA	114.818	156.60	2072	7.30	1.78	5.786	3	[Kr]$4d^{10}5s^2p^1$
50	Sn	Tin	14 IVB IVA	118.710	231.93	2602	7.28	1.96	7.344	2,4	[Kr]$4d^{10}5s^2p^2$
51	Sb	Antimony	15 VB VA	121.757	630.63	1587	6.684 $^{25°C}$	2.05	8.641	±3,5	[Kr]$4d^{10}5s^2p^3$
52	Te	Tellurium	16 VIB VIA	127.60	449.51	988	6.25	2.1	9.009	−2,4,6	[Kr]$4d^{10}5s^2p^4$
53	I	Iodine	17 VIIB VIIA	126.90447	113.7	184.4	4.93	2.66	10.451	±1,5,7	[Kr]$4d^{10}5s^2p^5$
54	Xe	Xenon	18 VIII 0	131.29	−111.75	−108.04	5.89	–	12.130		[Kr]$4d^{10}5s^2p^6$
55	Cs	Cesium	1 IA IA	132.90543	28.44	671	1.879	0.79	3.894	1	[Xe]$6s^1$
56	Ba	Barium	2 IIA IIA	137.327	727	1897	3.594	0.89	5.212	2	[Xe]$6s^2$
57	La •	Lanthanum	3 IIIA IIIB	138.9055	920	3455	6.146	1.10	5.577	3	[Xe]$5d^16s^2$
72	Hf	Hafnium	4 IVA IVB	178.49	2233	4603	13.31	1.3	7.0	4	[Xe]$4f^{14}5d^26s^2$
73	Ta	Tantalum	5 VA VB	180.9479	3017	5458	16.6	1.5	7.89	5	[Xe]$4f^{14}5d^36s^2$
74	W	Tungsten	6 VIA VIB	183.84	3422	5555	19.35	2.36	7.98	2,3,4,5,6	[Xe]$4f^{14}5d^46s^2$
75	Re	Rhenium	7 VIIA VIIB	186.207	3186	5596	20.5	1.9	7.88	−1,2,4,6,7	[Xe]$4f^{14}5d^56s^2$
76	Os	Osmium	8 VIIIA VIII	190.23	3033	5012	22.61	2.2	8.7	2,3,4,6,8	[Xe]$4f^{14}5d^66s^2$
77	Ir	Iridium	9 VIIIA VIII	192.22	2446	4428	22.65	2.20	9.1	2,3,4,6	[Xe]$4f^{14}5d^76s^2$
78	Pt	Platinum	10 VIIIA VIII	195.08	1768.4	3825	21.45	2.28	9.0	2,4	[Xe]$4f^{14}5d^96s^1$
79	Au	Gold	11 IB IB	196.96654	1064.18	2856	19.31	2.54	9.225	1,3	[Xe]$4f^{14}5d^{10}6s^1$
80	Hg	Mercury	12 IIB IIB	200.59	−38.83	356.73	13.546	2.00	10.437	1,2	[Xe]$4f^{14}5d^{10}6s^2$
81	Tl	Thallium	13 IIIB IIIA	204.3833	304	1473	11.85	2.04	6.108	1,3	[Xe]$4f^{14}5d^{10}6s^2p^1$
82	Pb	Lead	14 IVB IVA	207.2	327.46	1749	11.34	2.33	7.416	2,4	[Xe]$4f^{14}5d^{10}6s^2p^2$
83	Bi	Bismuth	15 VB VA	208.98037	271.40	1564	9.78	2.02	7.289	3,5	[Xe]$4f^{14}5d^{10}6s^2p^3$
84	Po	Polonium	16 VIB VIA	(208.9824)	254	962	9.196	2.0	8.42	2,4	[Xe]$4f^{14}5d^{10}6s^2p^4$
85	At	Astatine	17 VIIB VIIA	(209.9871)	302	337	–	2.2	–	±1,3,5,7	[Xe]$4f^{14}5d^{10}6s^2p^5$
86	Rn	Radon	18 VIII 0	(222.0176)	−71	−61.7	9.73	–	10.748		[Xe]$4f^{14}5d^{10}6s^2p^6$
87	Fr	Francium	1 IA IA	(223.0197)	27	677	–	0.7	–	1	[Rn]$7s^1$
88	Ra	Radium	2 IIA IIA	(226.0254)	700	<1140	5.8	0.9	5.279	2	[Rn]$7s^2$
89	Ac ••	Actinium	3 IIIA IIIB	(227.0278)	1051	3198	10.07	1.1	6.9	3	[Rn]$6d^17s^2$
104	Unq	Unnilquadium	4 IVA IVB	(261.11)	–	–	–	–	–	4	[Rn]$5f^{14}6d^27s^2$
105	Unp	Unnilpentium	5 VA VB	(262.114)	–	–	–	–	–	–	[Rn]$5f^{14}6d^37s^2$
106	Unh	Unnilhexium	6 VIA VIB	(263.118)	–	–	–	–	–	–	[Rn]$5f^{14}6d^47s^2$
107	Uns	Unnilseptium	7 VIIA VIIB	(262.12)	–	–	–	–	–	–	[Rn]$5f^{14}6d^57s^2$
108	Uno	Unniloctium	8 VIIIA VIII	(265)	–	–	–	–	–	–	[Rn]$5f^{14}6d^67s^2$
109	Une	Unnilennium	9 VIIIA VIII	(266)	–	–	–	–	–	–	[Rn]$5f^{14}6d^77s^2$
110	Uun	Ununnilium	10 VIIIA VIII	(272)	–	–	–	–	–	–	
58	Ce •	Cerium		140.115	799	3424	6.770	1.12	5.466	3,4	[Xe]$4f^15d^16s^2$
59	Pr •	Praseodymium		140.90765	931	3510	6.773	1.13	5.422	3,4	[Xe]$4f^36s^2$
60	Nd •	Neodymium		144.24	1016	3066	7.00	1.14	5.489	3	[Xe]$4f^46s^2$
61	Pm •	Promethium		(144.9127)	1042	3000	7.264	1.13	5.554	3	[Xe]$4f^56s^2$
62	Sm •	Samarium		150.36	1072	1790	7.536	1.17	5.631	2,3	[Xe]$4f^66s^2$
63	Eu •	Europium		151.965	822	1596	5.244	1.2	5.666	2,3	[Xe]$4f^76s^2$
64	Gd •	Gadolinium		157.25	1314	3264	7.901	1.20	6.141	3	[Xe]$4f^75d^16s^2$
65	Tb •	Terbium		158.92534	1359	3221	8.230	1.2	5.842	3,4	[Xe]$4f^96s^2$
66	Dy •	Dysprosium		162.50	1411	2561	8.551	1.22	5.927	3	[Xe]$4f^{10}6s^2$
67	Ho •	Holmium		164.93032	1472	2694	8.80	1.23	6.018	3	[Xe]$4f^{11}6s^2$
68	Er •	Erbium		167.26	1529	2862	9.066	1.24	6.101	3	[Xe]$4f^{12}6s^2$
69	Tm •	Thulium		168.93421	1545	1946	9.321	1.25	6.18436	2,3	[Xe]$4f^{13}6s^2$
70	Yb •	Ytterbium		173.04	824	1194	6.966	1.1	6.25394	2,3	[Xe]$4f^{14}6s^2$
71	Lu •	Lutetium		174.967	1663	3393	9.84	1.27	5.42589	3	[Xe]$4f^{14}5d^16s^2$
90	Th ••	Thorium		232.0381	1750	4788	11.72	1.3	6.08	4	[Rn]$6d^27s^2$
91	Pa ••	Protactinium		231.03588	1572	–	15.37	1.5	5.89	4,5	[Rn]$5f^26d^17s^2$
92	U ••	Uranium		238.0289	1135	4131	19.05±0.02	1.38	6.05	3,4,5,6	[Rn]$5f^36d^17s^2$
93	Np ••	Neptunium		(237.0482)	644	–	20.45	1.36	6.19	3,4,5,6	[Rn]$5f^46d^17s^2$
94	Pu ••	Plutonium		(244.0642)	640	3228	19.816	1.28	5.8	3,4,5,6	[Rn]$5f^67s^2$
95	Am ••	Americium		(243.0614)	1176	2607	13.67	1.3	5.993	3,4,5,6	[Rn]$5f^77s^2$
96	Cm ••	Curium		(247.0703)	1345	–	13.51	1.3	6.02	3	[Rn]$5f^76d^17s^2$
97	Bk ••	Berkelium		(247.0703)	1050	–	14.78	1.3	6.23	3,4	[Rn]$5f^97s^2$
98	Cf ••	Californium		(251.0796)	900	–	–	1.3	6.30	3	[Rn]$5f^{10}7s^2$
99	Es ••	Einsteinium		(252.083)	860	–	–	1.3	6.42	3	[Rn]$5f^{11}7s^2$
100	Fm ••	Fermium		(257.0951)	1527	–	–	1.3	6.50	3	[Rn]$5f^{12}7s^2$
101	Md ••	Mendelevium		(258.10)	827	–	–	1.3	6.58	2,3	[Rn]$5f^{13}7s^2$
102	No ••	Nobelium		(259.1009)	827	–	–	1.3	6.65	2,3	[Rn]$5f^{14}7s^2$
103	Lr ••	Lawrencium		(262.11)	1627	–	–	–	–	3	[Rn]$5f^{14}6d^17s^2$

*indicates approximate values and/or inconsistent literature data.

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]

Group Classifications	7 VIIA VIIB
Atomic Weight	54.93805
Atomic Number	25
Melting Point	1246
Boiling Point	2061
Oxidation States	2,3,4,6,7
Density	7.47
Electronegativity	1.55
First Ionization Potential	7.435
Symbol	Mn
Electronic Configuration	[Ar]$3d^54s^2$
Name	Manganese

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).

PAPERTECH

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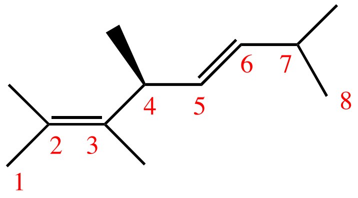
1. (5 pts) What is the most important question in organic chemistry?

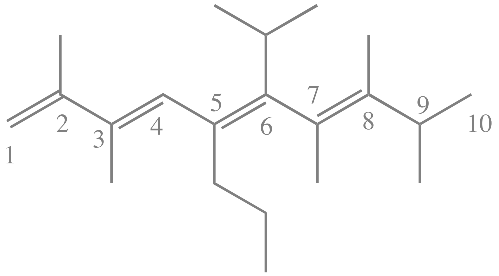
Where are the electrons?

2. (10 pts) Write an acceptable IUPAC name for the following two molecules. Where appropriate, use E and Z or R and S.



(4*S*,5*E*)-2,3,4,7-tetramethyl-2,5-octadiene

This problem was deleted to shorten the exam

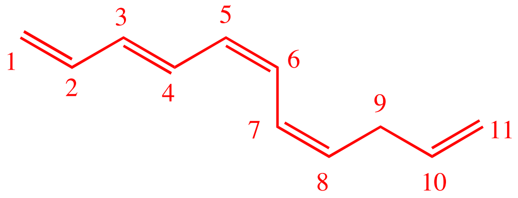


(3*E*,5*E*,7*E*)-6-isopropyl-2,3,7,8,9-pentamethyl-5-propyl-1,3,5,7-decatetraene

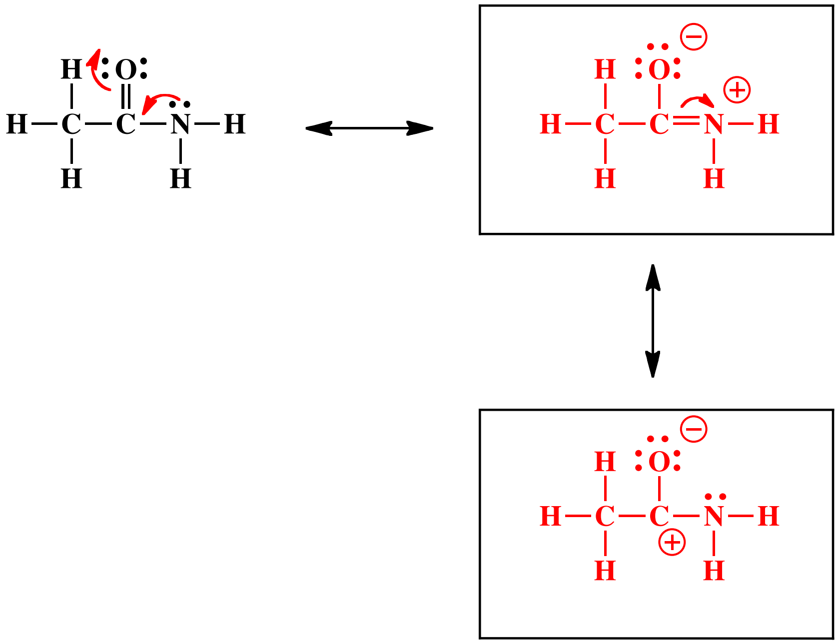
(3*E*,5*E*,7*E*)-2,3,7,8,9-pentamethyl-6-(1-methylethyl)-5-propyl-1,3,5,7-decatetraene

3. (5 pts) Draw the structure that corresponds to the following name:

(3*E*,5*Z*,7*Z*)-1,3,5,7,10-undecapentaene



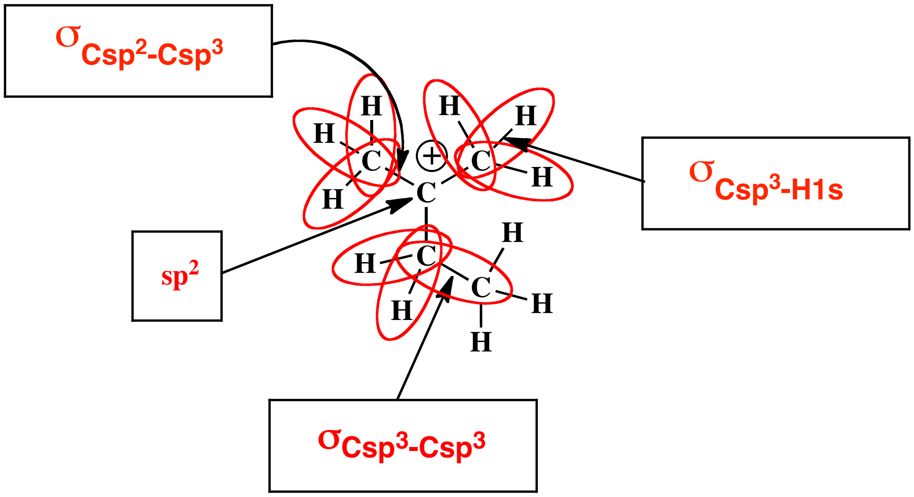
4. (10 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left in each problem, use arrows to indicate the movement 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. For the following carbocation:

A) State the hybridization state of the indicated atom in the square box provided. In the rectangular boxes, describe the bonds indicated by the arrows in terms of overlap between hybrid orbitals (the valence bond approach). For example, answers might be $\sigma_{Csp^3\text{-}Csp^3}$ or $\pi_{C2p\text{-}C2p}$.
Note that this part of the question is NOT about hyperconjugation. We just want a valence bond description of the bonding in a carbocation structure.

(2 pts. each)

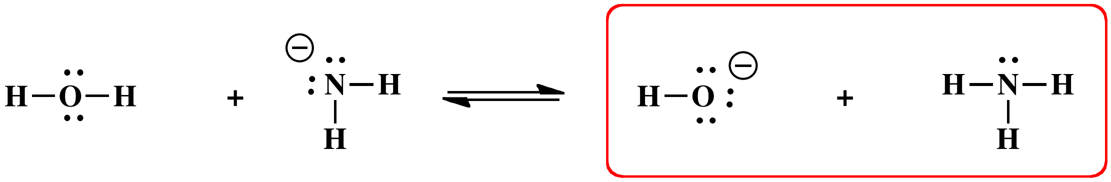


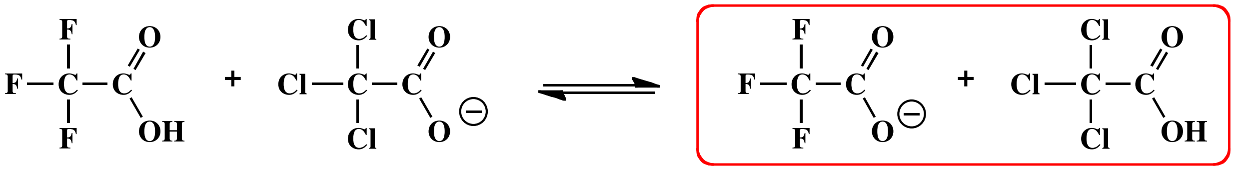
NOTICE THIS

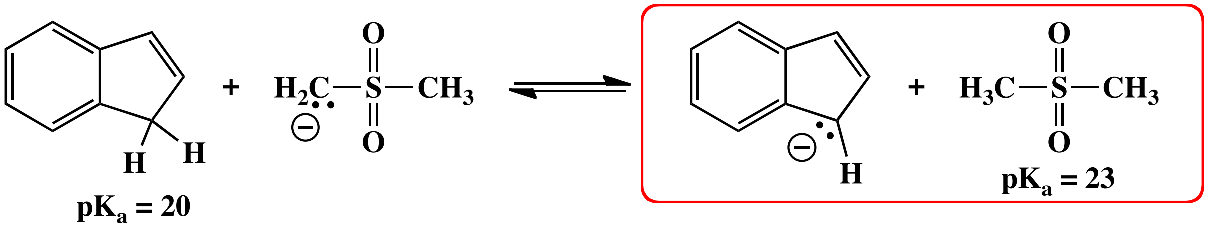
⇩

B) (6 pts) This part refers to hyperconjugation. On the structure, **circle all of the sigma bonds that can take part in hyperconjugation with the carbocation.**

6. (6 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.**







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 and alkynes as [✓ NUCLEOPHILES] or ELECTROPHILES that react with NUCLEOPHILES or [✓ ELECTROPHILES].

In general, [✓ NUCLEOPHILES] or ELECTROPHILES serve as electron sources and NUCLEOPHILES or [✓ ELECTROPHILES] serve as electron sinks for most 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 faster (greater opportunity) has a [✓ LOWER] or HIGHER activation energy.

A reation that has a strong thermodynamic driving force (a strong motive) is [✓ FAVORABLE] or UNFAVORABLE as written.

8. (2 pts each) Write the four most common mechanism elements seen in organic chemistry reaction mechanisms.

1. Make a bond between a nucleophile and an electrophile

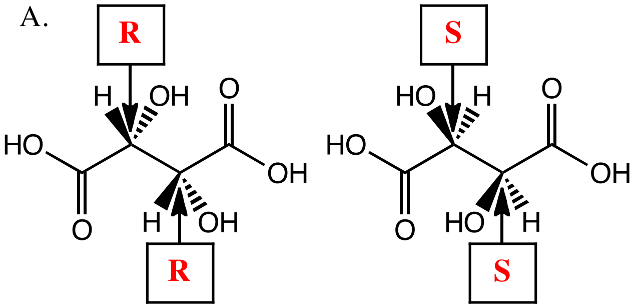
2. Break a bond to give stable molecules or ions

3. Add a proton

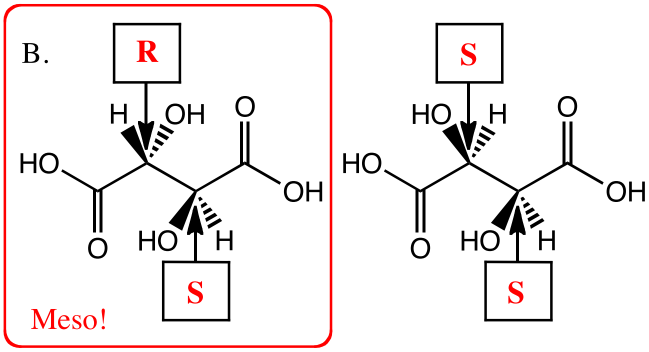
4. Take a proton away

9. (6 or 8 pts each) Label each stereocenter as "R" or "S" and on the line provided state whether the pair of molecules represent two enantiomers, two diastereomers, or the same compound.
Draw a circle around any meso compound.

A.

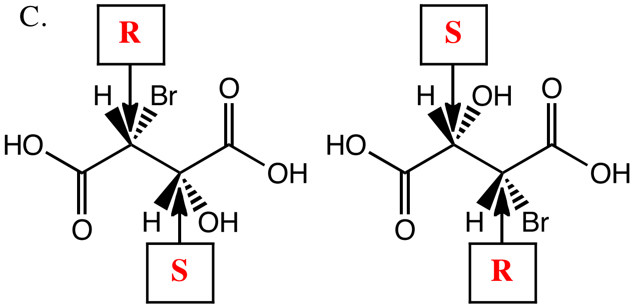


Enantiomers



Diastereomers

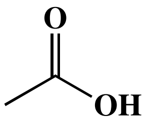
C.

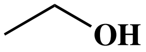


Same Compound

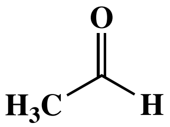
10. (2 pts each no partial credit) The following statements are true. Choose from among the following three possibilities and in the space provided, write the letter of the one *or more* phenomena that best explain the true statement.

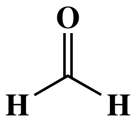
A. The inductive effect **B. Hyperconjugation** **C. Resonance delocalization of a charged species**



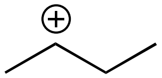
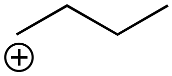
is a stronger acid than


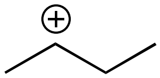
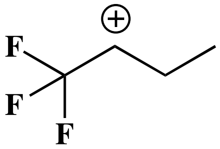
because of: C



is more acidic than


because of: C


is a more stable carbocation than

because of: A, B


is a more stable carbocation than


because of: A

11. (2 pts each no partial credit) The following statements describe some important properties of molecules. Choose from among the following three types of isomers and in the space provided write the letter of the one *or more* types of isomers for which the statemet is TRUE.

A. A single enantiomer **B. A meso compound** **C. A racemic mixture**

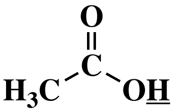
A solution of this will rotate the plane of plane polarized light. A

A solution of this will NOT rotate the plane of plane polarized light. B, C

Might be produced when an alkene with no chiral centers reacts with a non-chiral reagent such as H-Br or Br_2. B, C

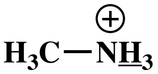
The LEAST desirable option when developing a new drug C

12. (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:**



$H_3C-C(=O)-O\underline{H}$

pK$_a$ = 4.76



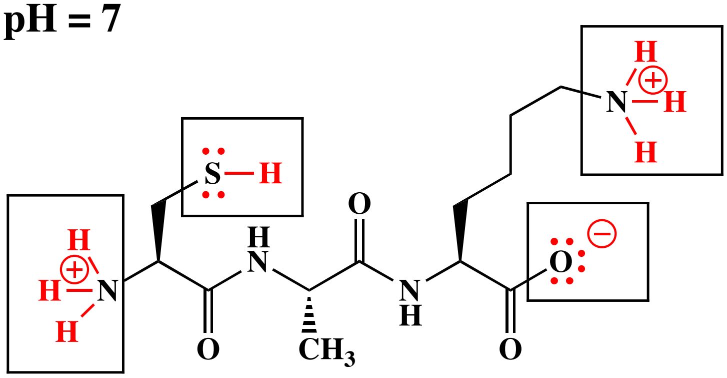
$H_3C-N^{\oplus}\underline{H}_3$

pK$_a$ = 10.64

$H_3CH_2C-S\underline{H}$

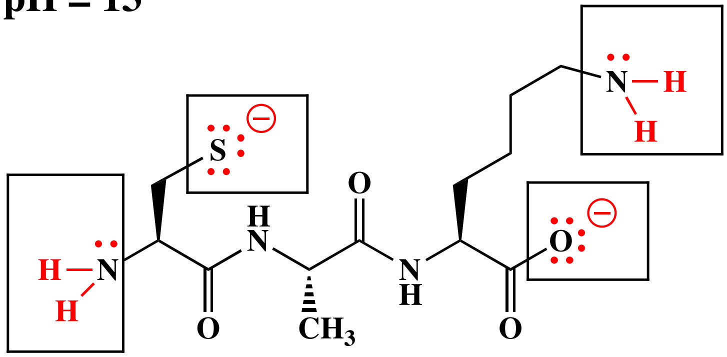
pK$_a$ = 10.6

pH = 7



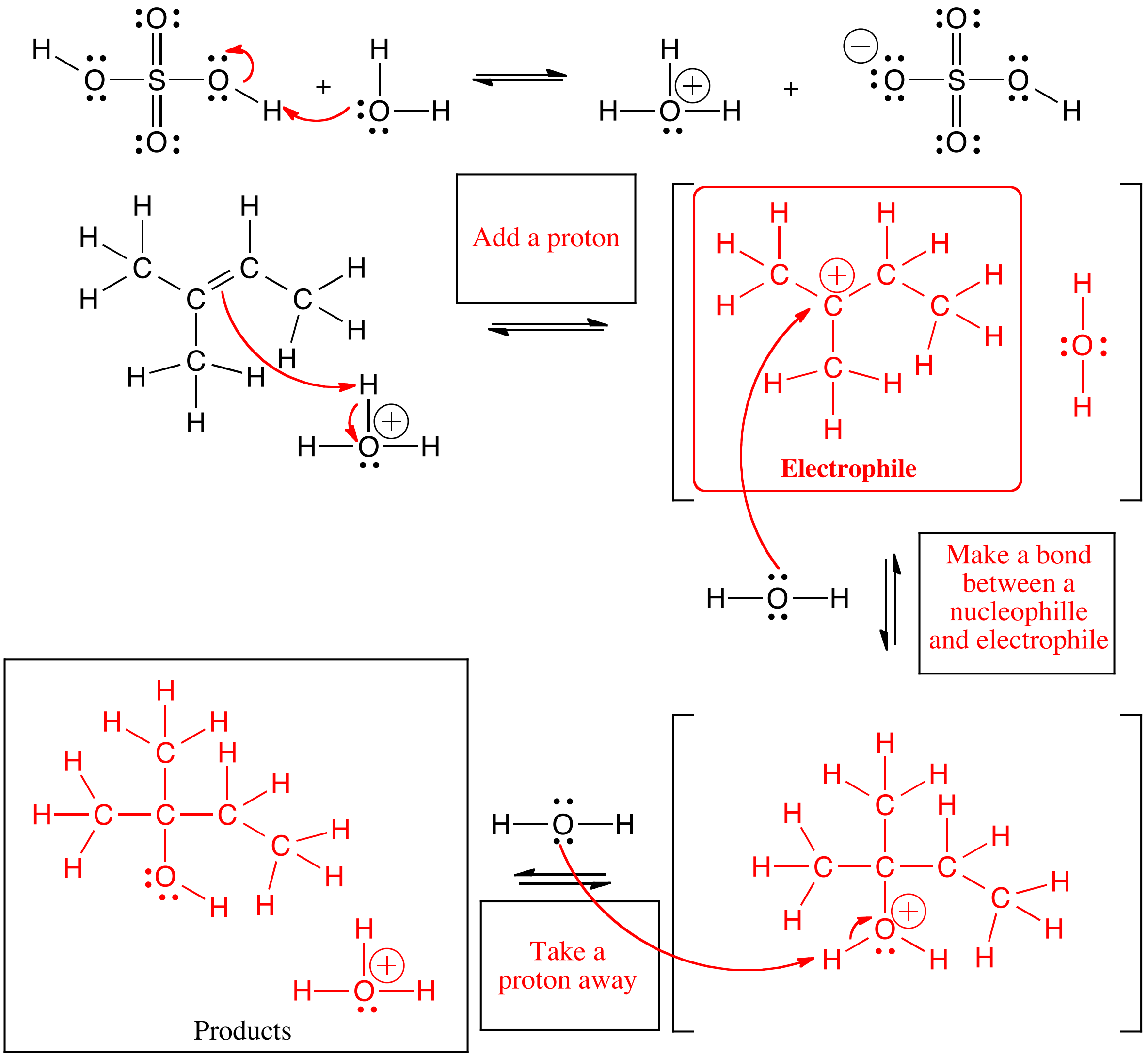
Total charge on molecule: +1

pH = 13



Total charge on molecule: -2

13. (16 pts.) Read these directions carefully. Read these directions carefully. (It was worth repeating) **For the reaction of an alkene with water and a small amount of sulfuric acid shown below, fill in the details of the mechanism. Draw the appropriate chemical structures and use an arrow to show how pairs of electrons are moved to** make and break bonds during the reaction. **For this question, you must draw all molecules produced in each step (yes, these equations need to be balanced!). Finally, fill in the boxes adjacent to the arrows with the type of step involved, such as "Make a bond" or Take a proton away". MAKE SURE TO NOTICE THE QUESTIONS AT THE BOTTOM. If an intermediate or product is chiral, you only need to draw one enantiomer for this problem.**

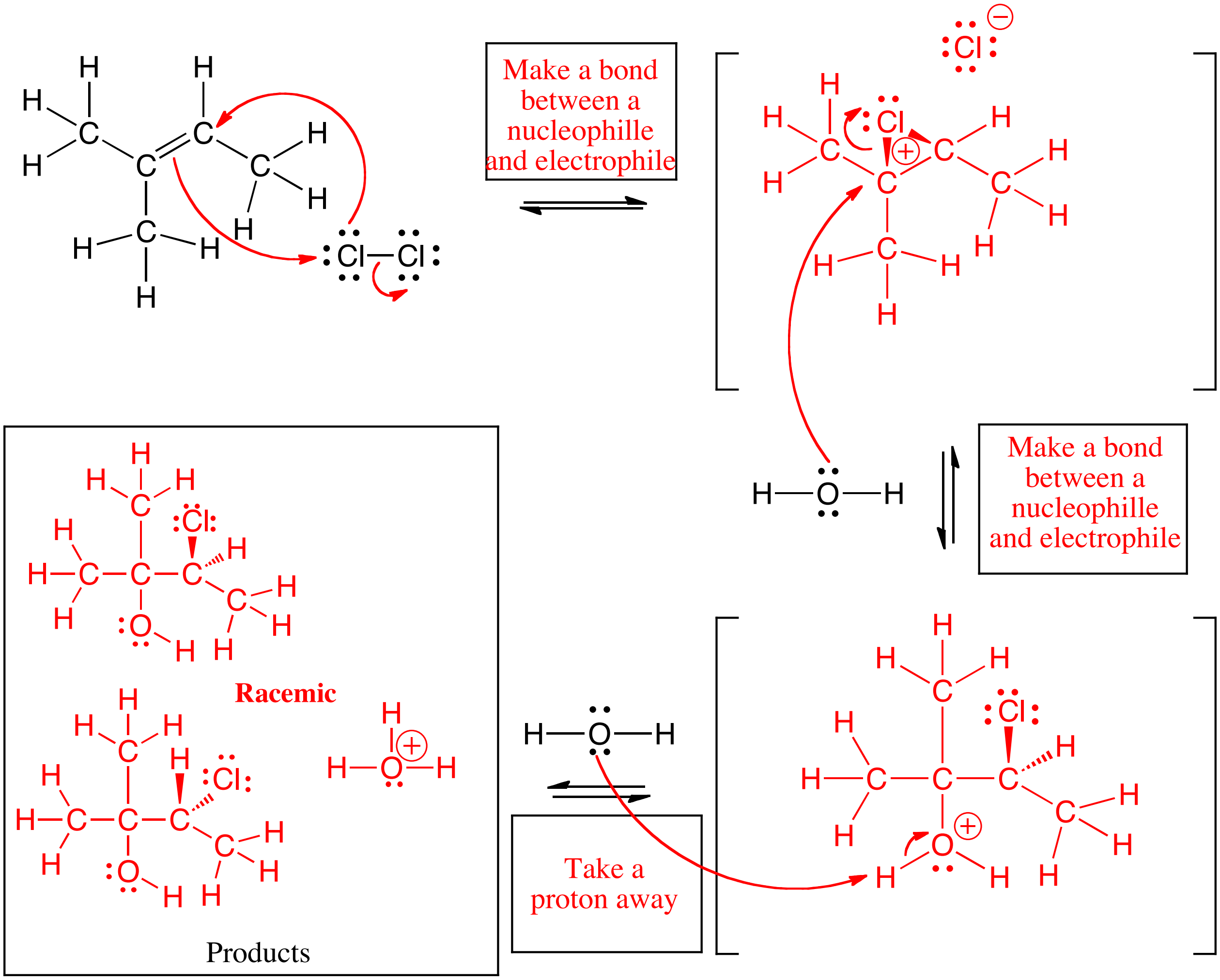


(2 pts) During the reaction described by the above mechanism, what happens to the pH of the solution **The pH stays the same because just as much acid is made as is used.**

(2 pts) Is this reaction catalytic in acid? **Yes**

(2 pts) One of the above steps involves making a bond between a nucleophile and an electrophile. Draw a circle around the electrophile.

14. (21 pts.) Read these directions carefully. Read these directions carefully. (It was worth repeating) **For the reaction of an alkene with water in the presence of Cl_2 shown below, fill in the details of the mechanism. Draw the appropriate chemical structures and use an arrow to show how pairs of electrons are moved to** make and break bonds during the reaction. **For this question, you must draw all molecules produced in each step (yes, these equations need to be balanced!). Finally, fill in the boxes adjacent to the arrows with the type of step involved, such as "Make a bond" or Take a proton away". MAKE SURE TO NOTICE THE QUESTIONS AT THE BOTTOM. If an intermediate or product is chiral, you only need to draw one enantiomer for this problem. For the product, you must draw both enantiomers and write "racemic" if appropriate.**

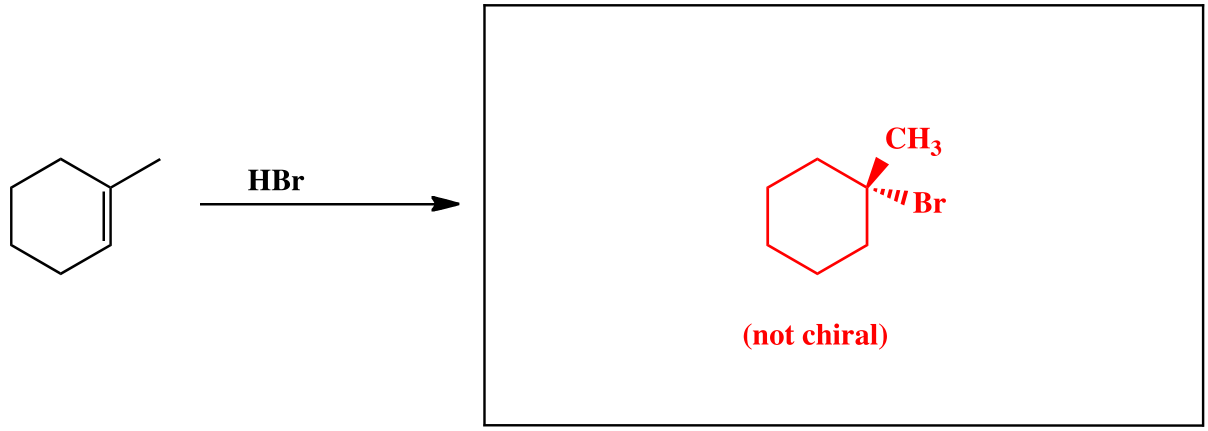


(2 pts) During the reaction described by the above mechanism, say what happens to the pH of the solution The pH drops because acid (H_3O^+) is produced

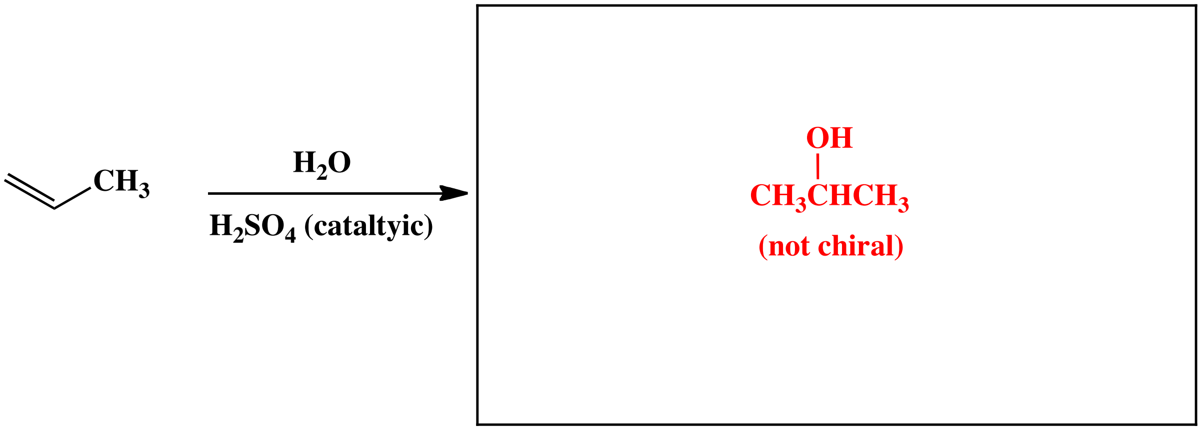
(2 pts) Is this reaction catalytic in acid? No, acid is produced

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 a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

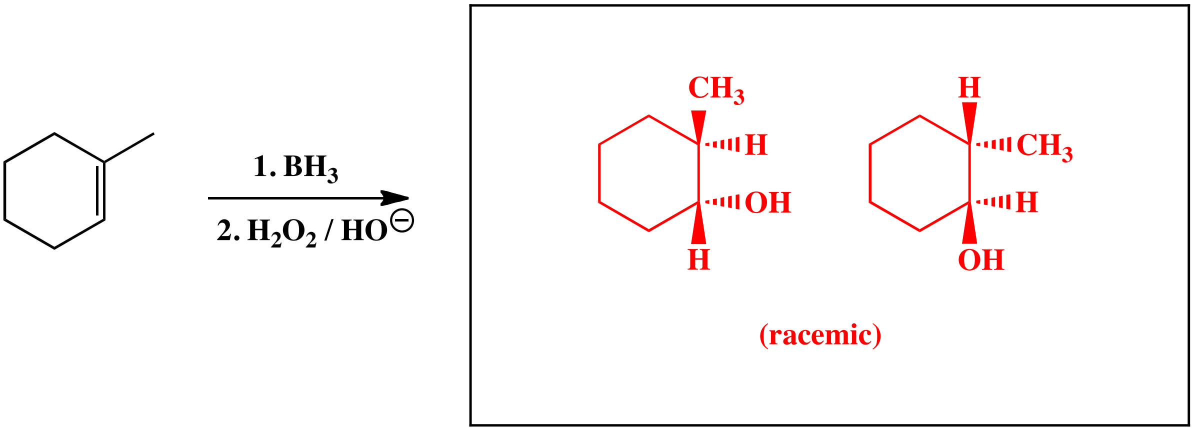
A.



B.

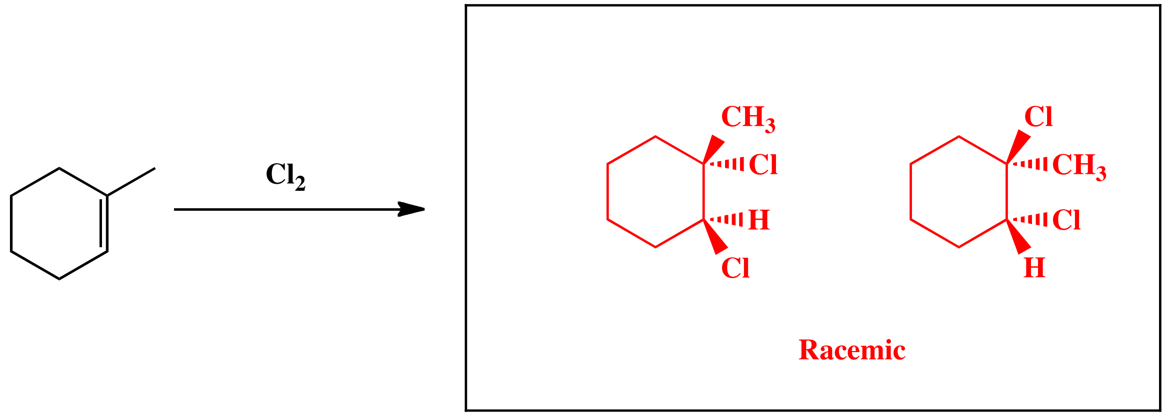


C.



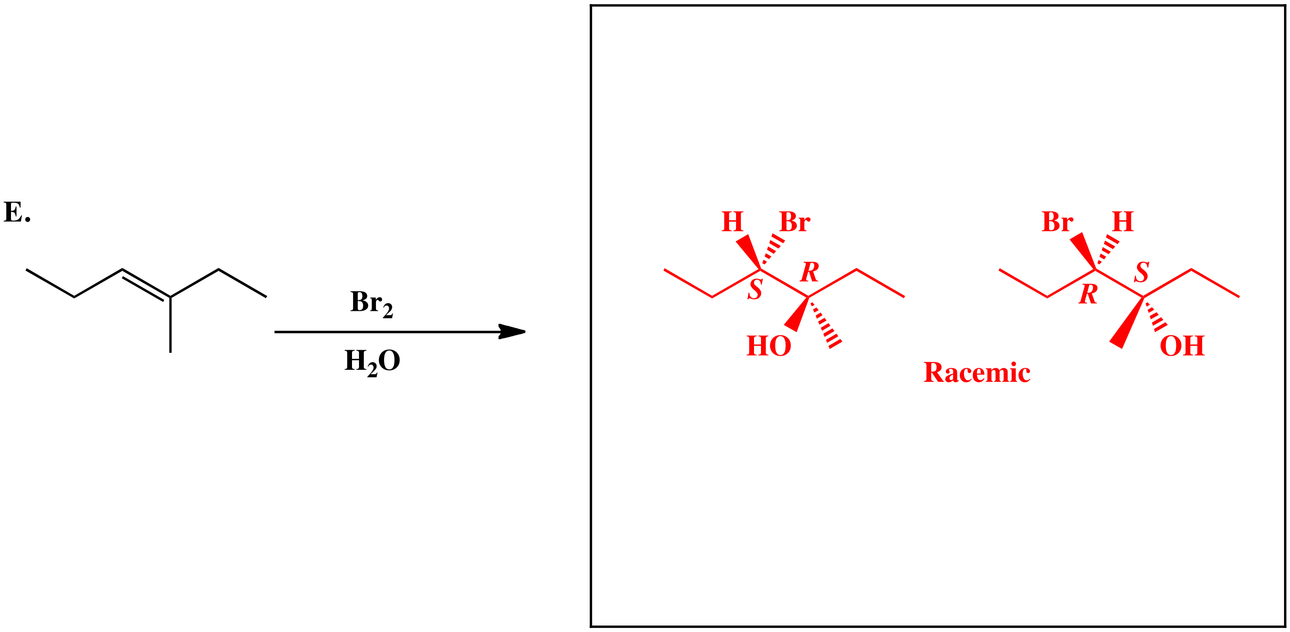
15. (cont.) (4 or 5 pts each) The following reactions all involve chemistry of alkenes. Fill in the box with the product(s) that are missing from the chemical reaction equations. **Draw only the predominant regioisomer product or products (i.e. Markovnikov or non-Markovnikov products)** and please remember that **you must draw the structures of all the product stereoisomers using wedges and dashes to indicate stereochemistry**. When a racemic mixture is formed, **you must write "racemic" under both structures EVEN THOUGH YOU DREW BOTH STRUCTURES**.

D.



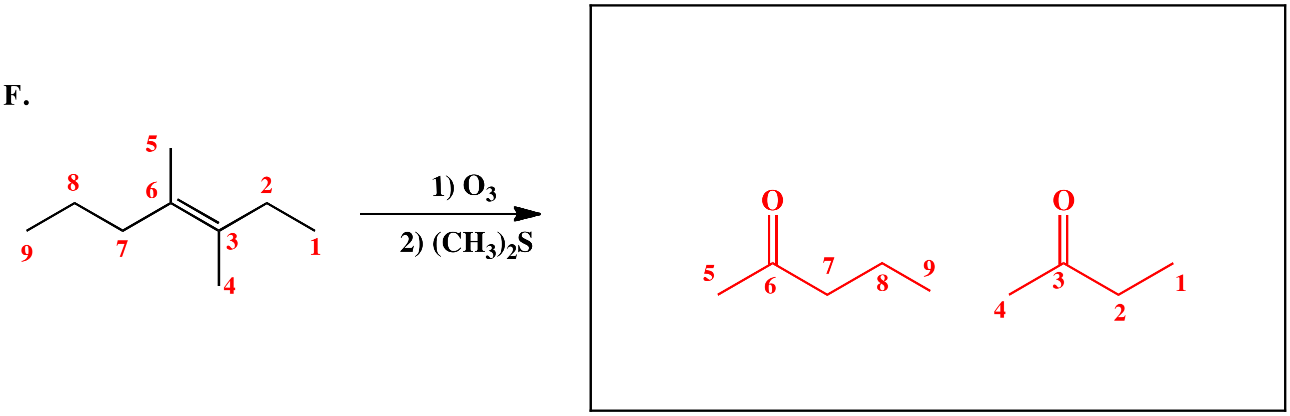
Racemic

E.

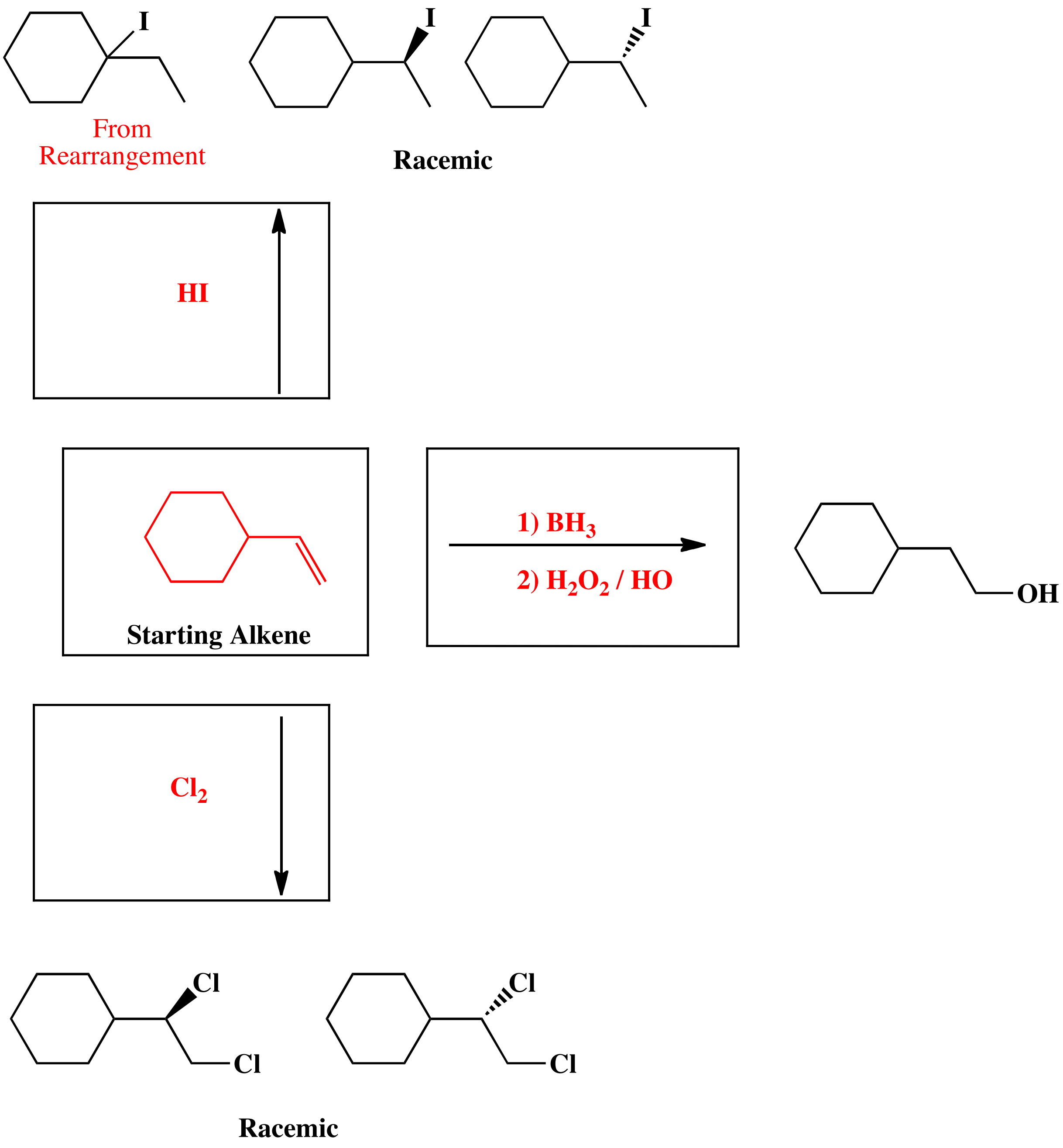


Racemic

F.

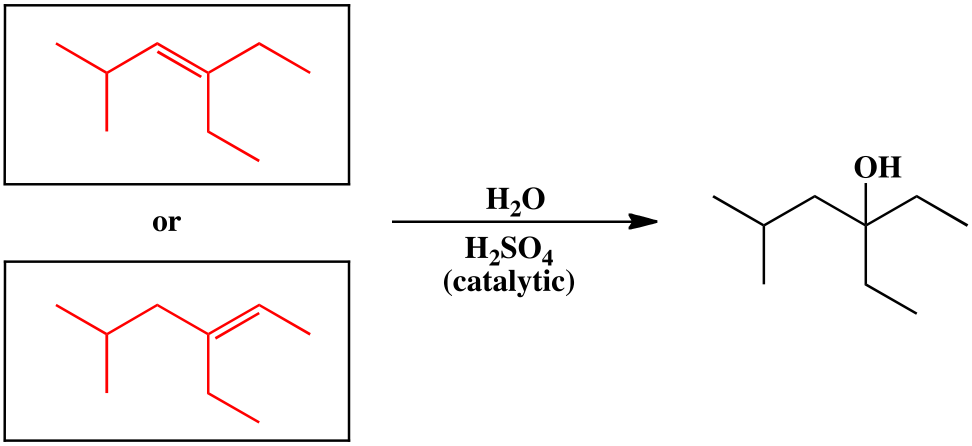


16. (13 pts total) Organic chemistry is a very creative science because there are so many different reactions known that often we are only limited by our imaginations. For example, the same starting alkene can be converted to the different products listed. **Deduce the identity of the starting alkene, 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.**

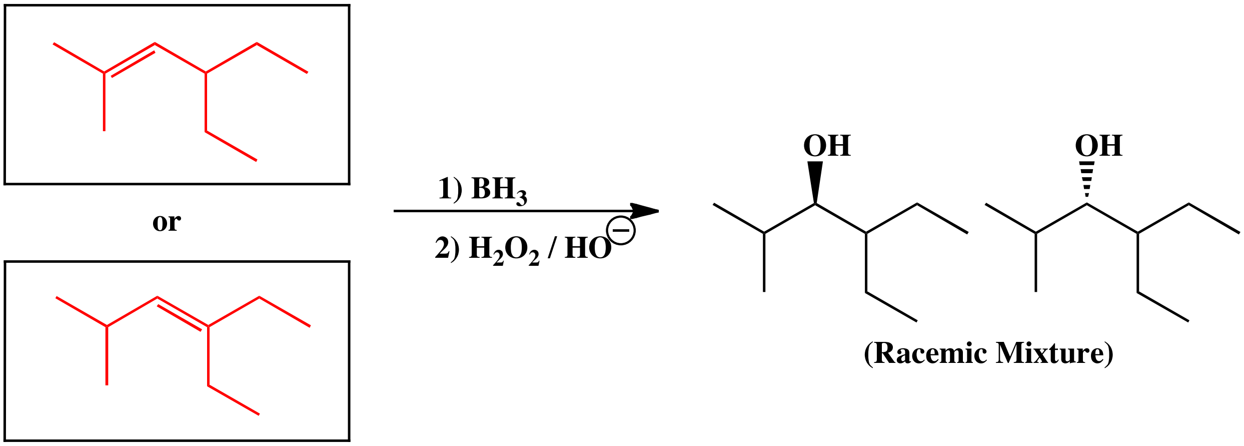


17. (6 pts each) The following problems are a new format. We turn the tables and give you the product. **In the space provided show the starting material required to make that product using the given reagents. When more than one starting material would work, you must draw both.**

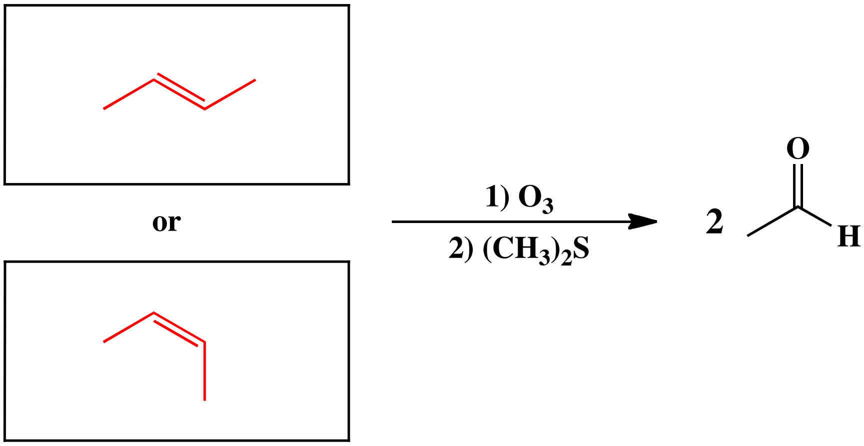
A.



B.



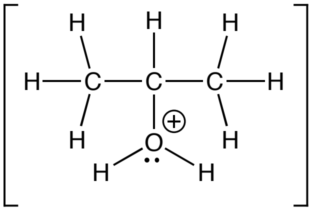
C.



18. Here is an "apply what you know" problem in the format of an MCAT style passage. Circle the correct answers.

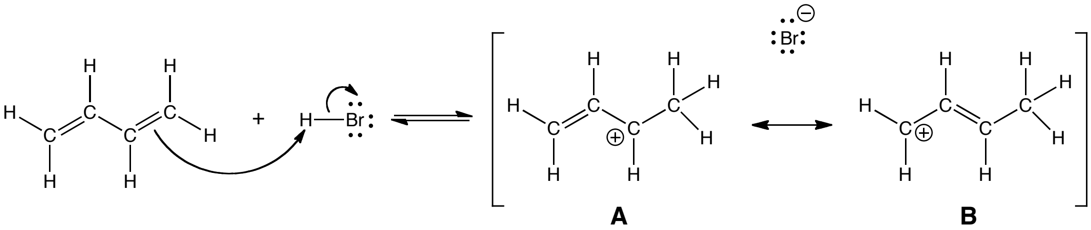
One of the more difficult things for new organic students to master is how to recognize an electrophile. One key piece of information is the charge you see on an atom. An atom with a full or partial positive charge is worth considering as an electrophile. However, not all atoms with a full or partial positive charge are electrophiles. To be an electrophile, an atom must be capable of acting as a "sink" for a mechanism arrow. In other words, it must be able to accept a new bond from an nucleophile. The best electrophile we have seen is a carbocation, capable of reaction with nucleophiles such as halide anions and water. As you continue your study of organic chemistry, you will encounter several other electrophiles. The following questions examine some of these. Although you have not seen all of them before, you are already familiar with all of the fundamental concepts you need to deduce the correct answers.

1. The following intermediate structure has a positive charge on the O atom.



A. The O atom is an electrophile because a nucleophile can add to it without causing the breaking of any of the other bonds to O.
B. The O atom is an electrophile because although it already has a filled valence, a proton (H^+) can depart as the new bond is made.
C. The O atom is not an electrophile because hyperconjugation stabilizes it.
D. The O atom is not an electrophile because it already has a filled valence and adding a new bond would require the creation of a very high energy species such as an H or C atom with a lone pair and thus negative charge.

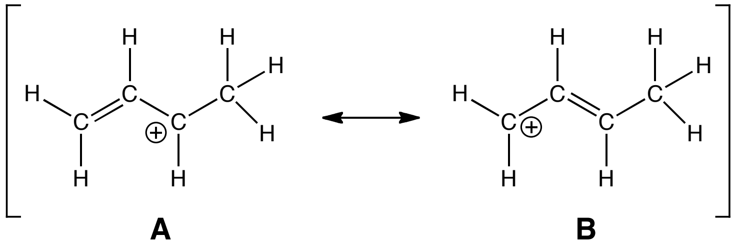
2. The following carbocation is encountered in a reaction you will study next semester.



A. The contributing structure A makes a larger contribution to the resonance hybrid.
B. The contributing structure B makes a larger contribution to the resonance hybrid.
C. The two contributing structures make equal contributions.
D. There is a third contributing structure that is not shown even though it makes the major contribution to the resonance hybrid.

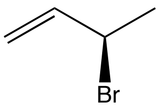
18. (cont.).

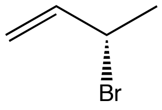
3. Here again is the same carbocation you saw in part 2.

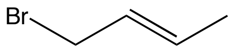


A. This carbocation is stabilized because it has a “pi-way”, that is a pi orbital that extends over more than two atoms.
B. This carbocation is stabilized by delocalization of the positive charge over more than one atom.
C. Both A and B.
D. This carbocation is less stable than an analogous carbocation that does not have an adjacent pi bond.

4. If the carbocation shown in parts 2 and 3 reacted with the bromide anion, one could imagine at least three different products that could form.







A. The product on the left is the only one that could form.
B. The product on the right is the only one that could form.
C. Only the product on the left and the product in the middle could form.
D. All three products could form.

5. Of the three products shown in part 4, which one(s) would you expect to be the most stable

A. The molecule on the left is the most stable
B. The molecule on the right is the most stable
C. The two molecules on the left have the same stability and they are both more stable than the molecule on the right.
D. All three molecules have the same stability