First Midterm Exar	First	Midterm	Exam
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Monday, January 24, 2022

Form	В
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Name			

You may use model kits but no other material with chemical information without instructor approval.

Please do not use any electronic gadgets.

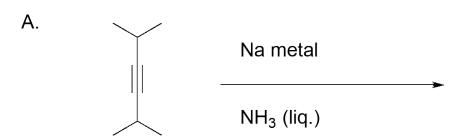
hydrogen	-		355	95%	1050	6	1570	10	3350	961	\$65%	300	960	790	850	7/7	10/3	helium
1																		2
Н																		He
1.0079																		4.0026
lithium	beryllium												boron	earbon	nitrogen	oxygen	fluorine	neon
3	_4												5	6		8	9	10
Li	Be												В	C	N	0	F	Ne
6.941	9.0122												10.811	12.011	14.007	15.999	18.998	20.180
sodium 11	magnesium 12												aluminium 13	silicon 14	phosphorus 15	sulfur 16	chlorine 17	argon 18
														70020	3896552		1000	
Na	Mg												Al	Si	Р	S	CI	Ar
22.990	24.305			Winds		I salaman tama		Tana		atata t		200	26.982	28.086	30.974	32.065	35.453	39.948
potassium 19	calcium 20		scandium 21	titanium 22	vanadium 23	chromium 24	manganese 25	iron 26	cobalt 27	nickel 28	copper 29	zinc 30	gallium 31	germanium 32	arsenic 33	selenium 34	bromine 35	krypton 36
	C-		C	T-:	1//	Cu	N/I	F			C	7:0		-	A -	Ca	D	/
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078		44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
39.098 rubidium	40.078 strontium		44.956 yttrium	47.867 zirconium	50.942 niobium	51.996 molybdenum	54.938 technetium	55,845 ruthenium	58,933 rhodium	58,693 palladium	63,546 silver	65,39 cadmium	69.723 indium	72.61 tin	74.922 antimony	78.96 tellurium	79.904 lodine	83.80 xenon
39.098 rubidium <b>37</b>	40.078 strontium 38		44.956	47.867 zirconium <b>40</b>	50.942 niobium <b>41</b>	51.996 molybdenum 42	54.938 technetium 43	55.845 ruthenium <b>44</b>	58.933 rhodium <b>45</b>	58.693 palladium <b>46</b>	63,546 silver 47	65,39 cadmium <b>48</b>	69.723 Indium 49	72.61 tin <b>50</b>	74.922 antimony <b>51</b>	78.96 tellurium <b>52</b>	79.904	83.80 xenon <b>54</b>
39,098 rubidium 37 <b>Rb</b>	strontium 38 Sr		44.956 yttrium 39	47.867 zirconium 40 Zr	50.942 niobium 41 <b>Nb</b>	51.996 molybdenum 42 Mo	54.938 technetium 43 <b>TC</b>	55,845 ruthenium 44 Ru	58,933 rhodium 45 <b>Rh</b>	58.693 palladium 46 Pd	63,546 silver 47 <b>Ag</b>	65.39 cadmium 48 Cd	69.723 Indium 49	72.61 tin 50 <b>Sn</b>	74.922 antimony 51 <b>Sb</b>	78.96 tellurium 52 <b>Te</b>	79.904 lodine 53	83.80 xenon 54 <b>Xe</b>
39,098 rubidium 37 <b>Rb</b> 85,468	40.078 strontium 38 <b>Sr</b> 87.62		44.956 yttrium 39 <b>Y</b> 88.906	47.867 zirconium 40 <b>Zr</b> 91.224	50.942 nlobium 41 Nb 92.906	51.996 molybdenum 42 Mo 95.94	54.938 technetium 43 <b>TC</b> [98]	55.845 ruthenium 44 <b>Ru</b> 101.07	58,933 rhodium 45 <b>Rh</b> 102,91	58.693 palladium 46 Pd 106.42	63,546 silver 47 <b>Ag</b> 107.87	65.39 cadmium 48 Cd 112.41	69.723 Indium 49 In	72.61 tin 50 <b>Sn</b> 118.71	74.922 antimony 51 <b>Sb</b> 121.76	78.96 tellurium 52 Te 127.60	79.904 lodine 53	83.80 xenon 54 Xe 131.29
39,098 rubidium 37 <b>Rb</b>	strontium 38 Sr	57-70	44.956 yttrium 39	47.867 zirconium 40 Zr	50.942 niobium 41 <b>Nb</b>	51.996 molybdenum 42 Mo	54.938 technetium 43 <b>TC</b>	55,845 ruthenium 44 Ru	58,933 rhodium 45 <b>Rh</b>	58.693 palladium 46 Pd	63,546 silver 47 <b>Ag</b>	65.39 cadmium 48 Cd	69.723 Indium 49	72.61 tin 50 <b>Sn</b>	74.922 antimony 51 <b>Sb</b>	78.96 tellurium 52 <b>Te</b>	79.904 lodine 53	83.80 xenon 54 <b>Xe</b>
39,098 rubidium 37 Rb 85,468 caesium 55	40.078 strontium 38 <b>Sr</b> 87.62 barium 56		44.956 yttrium 39 Y 88.906 lutetium 71	47.867 zirconium 40 Zr 91.224 hafnium 72	50.942 niobium 41 Nb 92.906 tantalum 73	51.996 molybdenum 42 Mo 95.94 tungsten 74	54.938 technetium 43 TC [98] rhenium 75	55,845 ruthenium 44 Ru 101.07 osmium 76	58.933 rhodium 45 <b>Rh</b> 102.91 iridium 77	58.693 palladium 46 Pd 106.42 platinum 78	63.546 silver 47 <b>Ag</b> 107.87 gold 79	65,39 cadmium 48 Cd 112.41 mercury 80	69.723 Indium 49 In 114.82 thallium 81	72.61 tin 50 <b>Sn</b> 118.71 lead 82	74.922 antimony 51 <b>Sb</b> 121.76 bismuth 83	78.96 tellurium 52 <b>Te</b> 127.60 polonium 84	79.904 lodine 53 126.90 astatine 85	83.80 xenon 54 Xe 131.29 radon 86
39,098 rubidium 37 Rb 85,468 caesium 55 Cs	40.078 strontium 38 Sr 87.62 barlum 56 Ba	57-70 <del>X</del>	44.956 yttrium 39 Y 88.906 lutetium 71 Lu	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf	50.942 nioblum 41 <b>Nb</b> 92.906 tantalum 73 <b>Ta</b>	51,996 molybdenum 42 Mo 95,94 tungsten 74 W	54.938 technetium 43 TC [98] rhenium 75 Re	ruthenium 44 Ru 101.07 osmium 76 Os	58,933 rhodium 45 Rh 102,91 iridium 77 Ir	palladium 46 Pd 106.42 platinum 78 Pt	63,546 silver 47 <b>Ag</b> 107,87 gold 79 <b>Au</b>	cadmium 48 Cd 112.41 mercury 80 Hg	69,723 indium 49 In 114,82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb	74.922 antimony 51 Sb 121.76 bismuth 83 Bi	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53   126.90 astatine 85   At	83.80 xenon 54 <b>Xe</b> 131.29 radon 86 <b>Rn</b>
39,098 rubidium 37 <b>Rb</b> 85,468 caesium 55 <b>Cs</b> 132,91	40.078 strontium 38 <b>Sr</b> 87.62 barium 56 <b>Ba</b> 137.33		44.956 yttrium 39 Y 88.906 lutetium 71 Lu 174.97	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95	51,996 molybdenum 42 Mo 95,94 tungsten 74 W	54.938 technelium 43 TC [98] thenium 75 Re 186.21	55,845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23	58,933 rhodium 45 Rh 102,91 ridium 77 Ir 192,22	58,693 palladium 46 Pd 106.42 platinum 78 Pt 195.08	63,546 silver 47 Ag 107,87 gold 79 Au 196,97	65,39 cadmium 48 Cd 112,41 mercury 80 Hg 200,59	69.723 Indium 49 In 114.82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2	74.922 antimony 51 <b>Sb</b> 121.76 bismuth 83	78.96 tellurium 52 <b>Te</b> 127.60 polonium 84	79.904 lodine 53 126.90 astatine 85	83.80 xenon 54 Xe 131.29 radon 86
39,098 rubidium 37 Rb 85,468 caesium 55 Cs	40.078 strontium 38 Sr 87.62 barlum 56 Ba		44.956 yttrium 39 Y 88.906 lutetium 71 Lu	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf	50.942 nioblum 41 <b>Nb</b> 92.906 tantalum 73 <b>Ta</b>	51,996 molybdenum 42 Mo 95,94 tungsten 74 W	54.938 technetium 43 TC [98] rhenium 75 Re	ruthenium 44 Ru 101.07 osmium 76 Os	58,933 rhodium 45 Rh 102,91 iridium 77 Ir	palladium 46 Pd 106.42 platinum 78 Pt	63,546 silver 47 <b>Ag</b> 107,87 gold 79 <b>Au</b>	cadmium 48 Cd 112.41 mercury 80 Hg	69,723 indium 49 In 114,82 thallium 81	72.61 tin 50 Sn 118.71 lead 82 Pb	74.922 antimony 51 Sb 121.76 bismuth 83 Bi	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53   126.90 astatine 85   At	83.80 xenon 54 <b>Xe</b> 131.29 radon 86 <b>Rn</b>
39,098 rubidium 37 Rb 85,468 caesium 55 Cs 132,91 francium 87	40.078 strontium 38 Sr 87.62 barlum 56 Ba 137.33 radium 88	<del>×</del> 89-102	44,956 yttrium 39 Y 88,906 lutetium 71 Lu 174,97 lawrencium 103	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium 104	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium 105	51,996 molybdenum 42 Mo 95,94 tungsten 74 W 183,84 seaborgium 106	54,938 technetium 43 TC [98] rhenium 75 Re 186,21 bohrium 107	55,845 ruthenium 44 Ru 101,07 osmium 76 OS 190,23 hassium 108	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 meitinerium 109	58,693 palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununnilium 110	63,546 silver 47 Ag 107,87 gold 79 Au 196,97 unununium 111	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 unurbium 112	69,723 indium 49 In 114.82 thallium 81 TI 204.38	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium 114	74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53   126.90 astatine 85   At	83.80 xenon 54 <b>Xe</b> 131.29 radon 86 <b>Rn</b>
39.098 rubidium 37 <b>Rb</b> 85.468 caesium 55 <b>Cs</b> 132.91 francium	40.078 strontium 38 Sr 87.62 barlum 56 Ba 137.33 radium	*	44,956 yttrium 39 Y 88,906 lutetium 71 Lu 174,97 lawrencium	47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium	50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium	51,996 molybdenum 42 Mo 95,94 tungsten 74 W 183,84 seaborgium	54,938 technetium 43 TC [98] thenium 75 Re 186,21 bohrium	55,845 ruthenium 44 Ru 101.07 osmium 76 Os 190.23 hassium	58,933 rhodium 45 Rh 102,91 iridium 77 Ir 192,22 meitnerium	58,693 palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununnilium 110	63,546 silver 47 Ag 107,87 gold 79 Au 196,97 unununium	65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 unurbium 112	69,723 indium 49 In 114.82 thallium 81 TI 204.38	72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium	74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	78.96 tellurium 52 Te 127.60 polonium 84 Po	79.904 iodine 53   126.90 astatine 85   At	83.80 xenon 54 <b>Xe</b> 131.29 radon 86 <b>Rn</b>

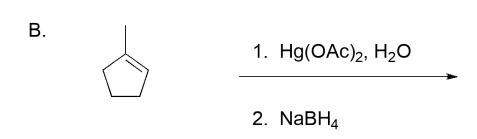
 $^{\star}$ Lanthanide series

\* \* Actinide series

	lanthanum 57	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70
l	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dv	Но	Er	Tm	Yb
ı	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
ĺ	actinium 89	thorium <b>90</b>	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	curium 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
l	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
١	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	12581	[259]

1. (30 points) Write the expected products for each of the following reactions. Specify stereochemistry where appropriate (you may write "racemic" in place of drawing a second enantiomer).





## 2. (25 points) Write (over the arrow) the reagents needed to accomplish the following transformations.

A.

В.

C.

(racemic)

D.

E.

F.

3. (20 points) Write mechanisms (using the correct electron-pushing formalism, and as many steps as needed) for each of the following transformations.

Α.

B. H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>O OH (as a mixture of diastereomers)

4. (16 points) Long-chain fatty alcohols are often observed to be chemical signaling agents in insect biochemistry. Fill in the boxes for intermediate structures or reagents in the following synthesis of (8S, 9S)-1,8,9-hexadecanetriol. (You may abbreviate using the  $(CH_2)_n$  formalism.)

Br 
$$\frac{1 \text{ eq. CaC}_2}{\text{=CH}_3(\text{CH}_2)_5\text{CH}_2\text{Br}}$$



$$= CH2=CH-(CH2)4CH2Br$$

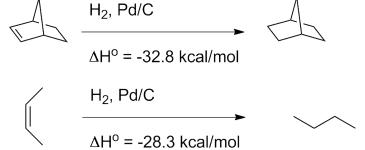
B.



\* This reagent reacts selectively with monosubstituted alkenes in the presence of more highly substututed alkenes

5. (9 points) The heat of hydrogenation for norbornene ([2.2.1]-bicyclo-hept-2-ene, shown at the right) is -32.8 kcal/mol.

Explain why this is different from that for Z-2-butene (-28.3 kcal/mol).



## Bond strengths (kcal/mol):

F-F	38
Cl-Cl	58
Br-Br	46
I-I	36
H-F	136
H-Cl	103
H-Br	87
H-I	71
CH₃-H	105
CH <sub>3</sub> CH <sub>2</sub> -H	101
(CH <sub>3</sub> ) <sub>2</sub> CH-H	98.5
(CH <sub>3</sub> ) <sub>3</sub> C-H	96.5
CH₃-F	110
CH₃-Cl	85
CH₃-Br	70
CH₃-I	57
CH₃CH₂-F	111
CH₃CH₂-Cl	84
CH₃CH₂-Br	70
CH₃CH₂-I	56
(CH3)2CH-F	111
(CH₃)₂CH-Cl	84
(CH₃)₂CH-Br	71
$(CH_3)_2CH-I$	56
(CH <sub>3</sub> ) <sub>3</sub> C-F	110
(CH₃)₃C-Cl	85
(CH₃)₃C-Br	71
(CH <sub>3</sub> ) <sub>3</sub> C-I	55

## Typical Heats of Hydrogenation