

Name: Answer Key  
(print legibly) Last FirstStudent ID Number: N/A

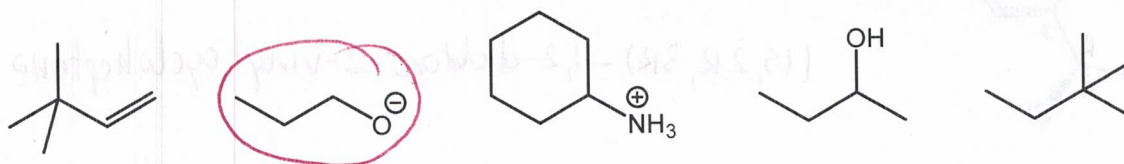
Read all directions very carefully. Write your answer legibly in the designated spaces and think carefully about what you are doing. The total number of points is 300. This exam is supposed to have six pages, with the last page intentionally left blank.

40

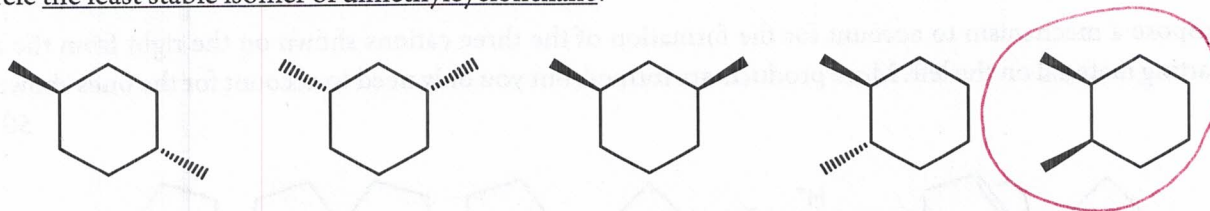
1. This question has several parts. In each part, **circle only one entry**.

Circle the most nucleophilic compound:

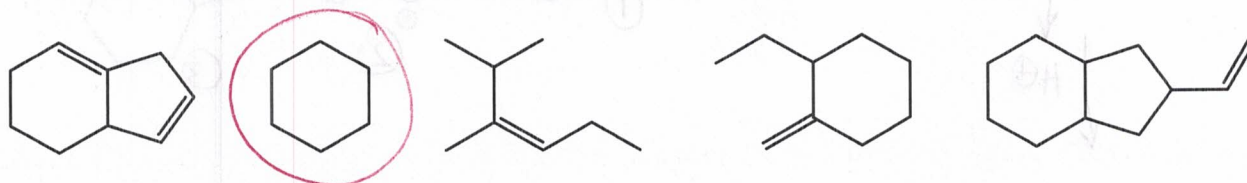
5×8 = 40 points



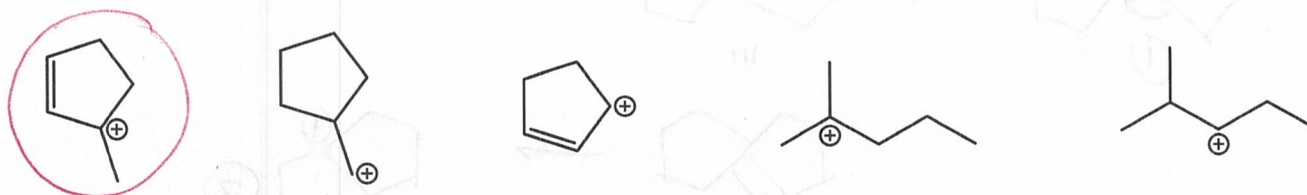
Circle the least stable isomer of dimethylcyclohexane:



Circle the only compound which does not react with HBr:



Circle the most stable cation (think about hyperconjugation and resonance):



The degree of unsaturation of atorvastation (Lipitor), which has molecular formula  $C_{33}H_{35}FN_2O_5$ , is:

1

4

12

17 (circled in red)

21

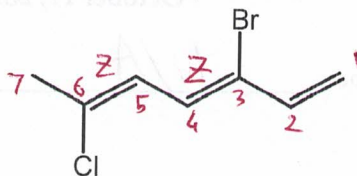
DO NOT WRITE  
IN THIS SPACE

310

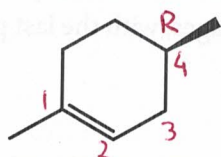
FINAL SCORE

30

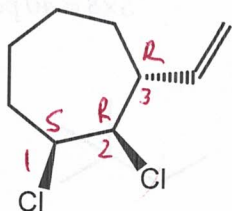
2. For each of the following structures, write their complete systematic IUPAC name. Be sure to indicate stereochemistry where this is pertinent. 3×10 = 30 points

~~4Z,6~~

(3Z,5Z)-3-bromo-6-chloro-1,3,5-heptatriene



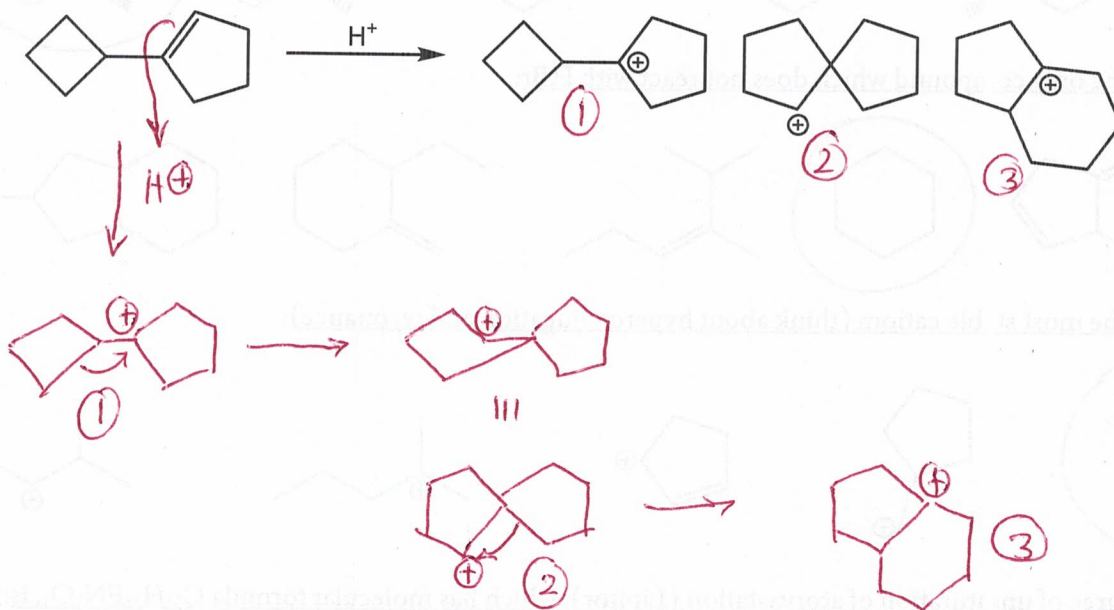
(R)-1,4-dimethylcyclohexene



(1S,2R,3R)-1,2-dichloro-2-vinylcycloheptane

50

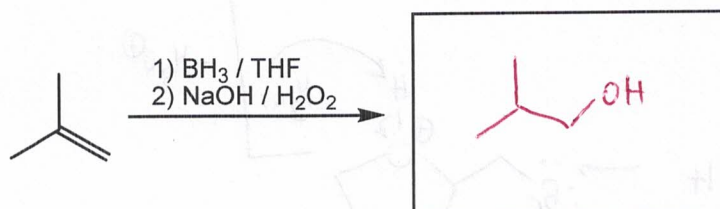
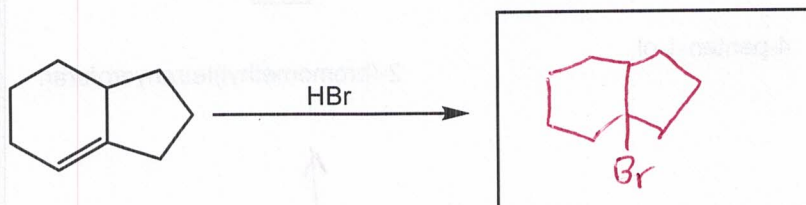
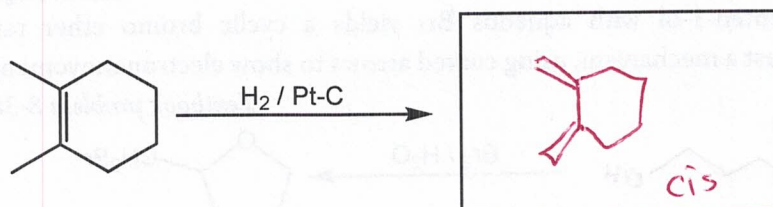
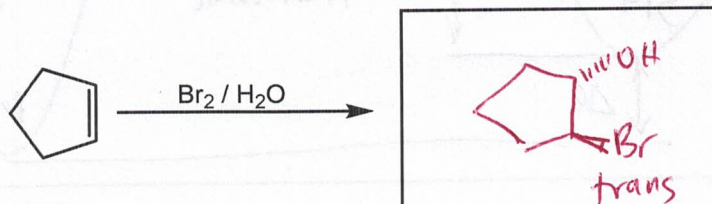
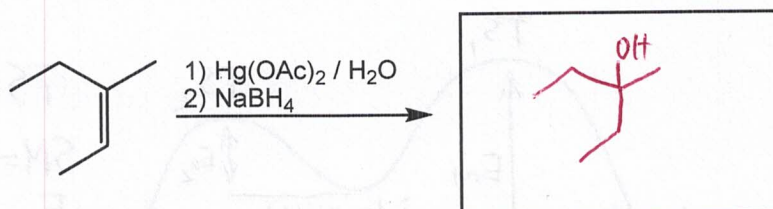
3. Propose a mechanism to account for the formation of the three cations shown on the right from the alkene starting material on the left. More products are formed, but you only need to account for the ones shown here. 50 points



60

4. For each of the reactions or series of reactions below, draw the structure of the missing major organic product(s) in the box(es) provided. Make sure to include all the pertinent information about stereochemistry and charges.

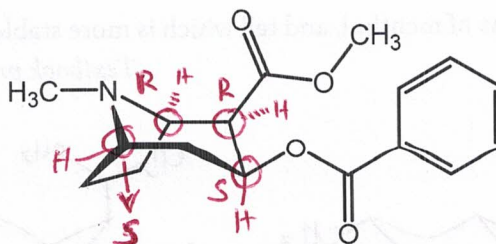
5×12 = 60 points



30

5. Shown below is the chemical structure of cocaine—a central nervous system stimulant and a common illegal drug. Circle all the stereocenters in cocaine.

20 points



BONUS: Pick any two stereocenters in cocaine and determine whether they have (R) or (S) configuration. Be clear on which stereocenters you are referring to.

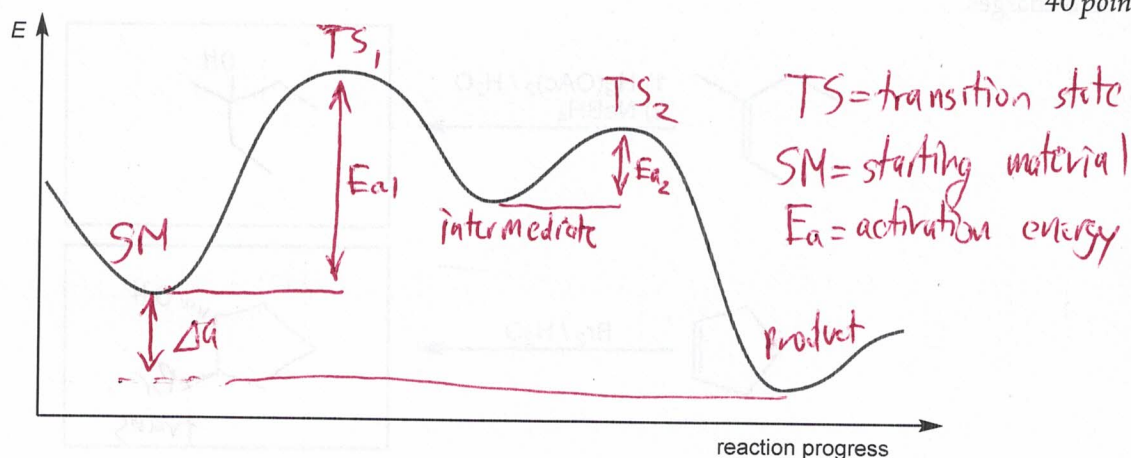
10 points



40

6. On the energy diagram shown below, clearly label (a) the activation energies for both steps, (b) the positions of the starting material, intermediate(s), transition state(s), and the product, and (c) the overall  $\Delta G$  of the reaction.

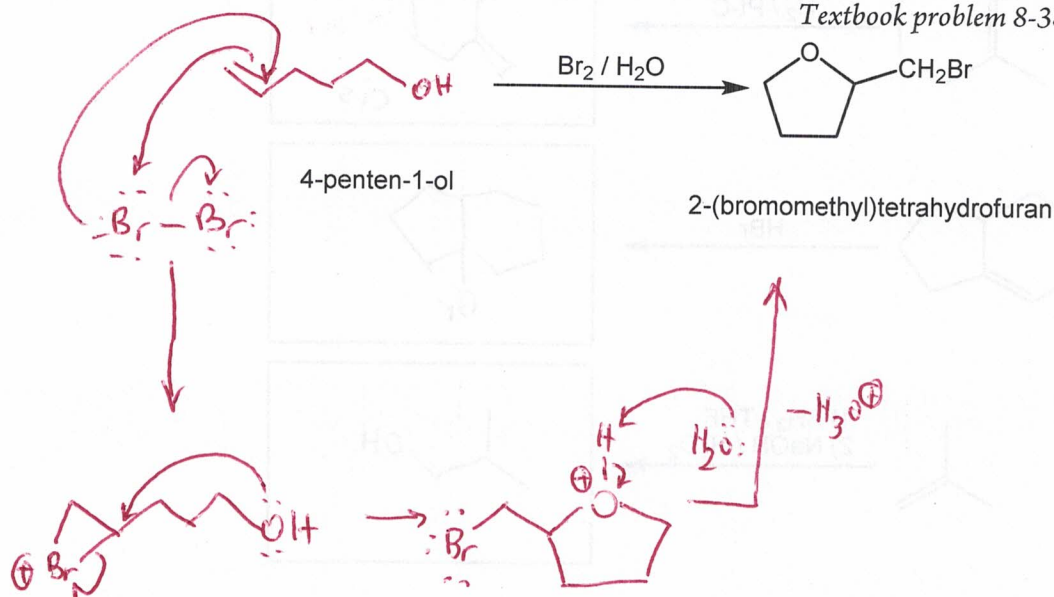
40 points



40

7. Treatment of 4-penten-1-ol with aqueous  $\text{Br}_2$  yields a cyclic bromo ether rather than the expected bromohydrin. Suggest a mechanism, using curved arrows to show electron movement.

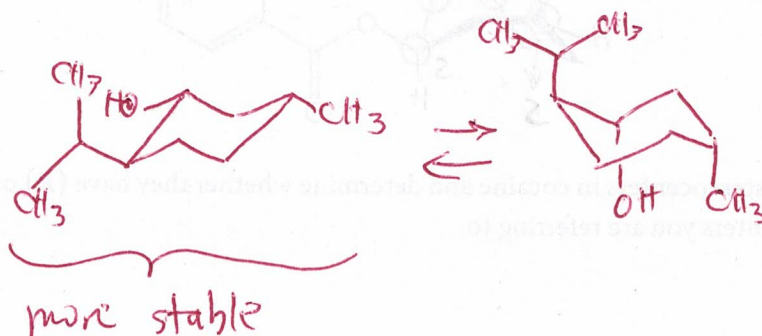
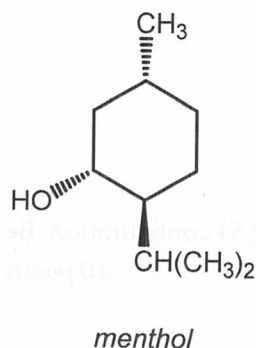
40 points

Textbook problem 8-38 (McMurry, 10<sup>th</sup> edition)

20

8. Draw the two chair conformations of menthol, and tell which is more stable.

20 points

Textbook problem 4-45 (McMurry, 10<sup>th</sup> edition)

|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                                            |
|---------------------------------------|----------------------------------------|---------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--------------------------------------------|
| hydrogen<br>1<br><b>H</b><br>1.0079   |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | helium<br>2<br><b>He</b><br>4.0026         |
| lithium<br>3<br><b>Li</b><br>6.941    | beryllium<br>4<br><b>Be</b><br>9.0122  |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | boron<br>5<br><b>B</b><br>10.811           |
| sodium<br>11<br><b>Na</b><br>22.990   | magnesium<br>12<br><b>Mg</b><br>24.305 |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | carbon<br>6<br><b>C</b><br>12.011          |
| potassium<br>19<br><b>K</b><br>39.098 | calcium<br>20<br><b>Ca</b><br>40.078   |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | nitrogen<br>7<br><b>N</b><br>14.007        |
| rubidium<br>37<br><b>Rb</b><br>85.468 | strontium<br>38<br><b>Sr</b><br>87.62  |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | oxygen<br>8<br><b>O</b><br>15.999          |
| cesium<br>55<br><b>Cs</b><br>132.91   | barium<br>56<br><b>Ba</b><br>137.33    | 57-70<br>*    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | fluorine<br>9<br><b>F</b><br>18.998        |
| francium<br>87<br><b>Fr</b><br>[223]  | radium<br>88<br><b>Ra</b><br>[226]     | 89-102<br>* * |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | neon<br>10<br><b>Ne</b><br>20.180          |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | argon<br>18<br><b>Ar</b><br>39.948         |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | potassium<br>39<br><b>K</b><br>39.098      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | calcium<br>20<br><b>Ca</b><br>40.078       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | scandium<br>21<br><b>Sc</b><br>44.956      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | titanium<br>22<br><b>Ti</b><br>47.867      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | vanadium<br>23<br><b>V</b><br>50.942       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | chromium<br>24<br><b>Cr</b><br>51.996      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | manganese<br>25<br><b>Mn</b><br>54.938     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | iron<br>26<br><b>Fe</b><br>55.845          |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | cobalt<br>27<br><b>Co</b><br>58.933        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | nickel<br>28<br><b>Ni</b><br>58.693        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | copper<br>29<br><b>Cu</b><br>63.546        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | zinc<br>30<br><b>Zn</b><br>65.39           |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | gallium<br>31<br><b>Ga</b><br>69.723       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | germanium<br>32<br><b>Ge</b><br>72.61      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | arsenic<br>33<br><b>As</b><br>74.922       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | selenium<br>34<br><b>Se</b><br>78.96       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | bromine<br>35<br><b>Br</b><br>79.904       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | krypton<br>36<br><b>Kr</b><br>83.80        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | rubidium<br>37<br><b>Rb</b><br>85.468      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | strontium<br>38<br><b>Sr</b><br>87.62      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | yttrium<br>39<br><b>Y</b><br>88.906        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | zirconium<br>40<br><b>Zr</b><br>91.224     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | niobium<br>41<br><b>Nb</b><br>92.906       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | molybdenum<br>42<br><b>Mo</b><br>95.94     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | technetium<br>43<br><b>Tc</b><br>[98]      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ruthenium<br>44<br><b>Ru</b><br>101.07     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | rhodium<br>45<br><b>Rh</b><br>102.91       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | palladium<br>46<br><b>Pd</b><br>106.42     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | silver<br>47<br><b>Ag</b><br>107.87        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | cadmium<br>48<br><b>Cd</b><br>112.41       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | indium<br>49<br><b>In</b><br>114.82        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | tin<br>50<br><b>Sn</b><br>118.71           |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | antimony<br>51<br><b>Sb</b><br>121.76      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | tellurium<br>52<br><b>Te</b><br>127.60     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | iodine<br>53<br><b>I</b><br>126.90         |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | xenon<br>54<br><b>Xe</b><br>131.29         |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | caesium<br>55<br><b>Cs</b><br>132.91       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | barium<br>56<br><b>Ba</b><br>137.33        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | lanthanum<br>57<br><b>La</b><br>138.91     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | cerium<br>58<br><b>Ce</b><br>140.12        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | praseodymium<br>59<br><b>Pr</b><br>140.91  |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | neodymium<br>60<br><b>Nd</b><br>144.24     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | promethium<br>61<br><b>Pm</b><br>[145]     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | samarium<br>62<br><b>Sm</b><br>150.36      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | europium<br>63<br><b>Eu</b><br>151.96      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | gadolinium<br>64<br><b>Gd</b><br>157.25    |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | terbium<br>65<br><b>Tb</b><br>158.93       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | dysprosium<br>66<br><b>Dy</b><br>162.50    |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | holmium<br>67<br><b>Hm</b><br>164.93       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | erbium<br>68<br><b>Er</b><br>167.26        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | thulium<br>69<br><b>Tm</b><br>168.93       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ytterbium<br>70<br><b>Yb</b><br>173.05     |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | lutetium<br>71<br><b>Lu</b><br>174.97      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | hafnium<br>72<br><b>Hf</b><br>178.49       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | tantalum<br>73<br><b>Ta</b><br>180.95      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | tungsten<br>74<br><b>W</b><br>183.84       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | rhenium<br>75<br><b>Re</b><br>186.21       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | osmium<br>76<br><b>Os</b><br>190.23        |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | iridium<br>77<br><b>Ir</b><br>192.22       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | platinum<br>78<br><b>Pt</b><br>195.08      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | gold<br>79<br><b>Au</b><br>196.97          |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | mercury<br>80<br><b>Hg</b><br>200.59       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | thallium<br>81<br><b>Tl</b><br>204.38      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | lead<br>82<br><b>Pb</b><br>207.2           |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | bismuth<br>83<br><b>Bi</b><br>208.98       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | polonium<br>84<br><b>Po</b><br>[209]       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | astatine<br>85<br><b>At</b><br>[210]       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | radon<br>86<br><b>Rn</b><br>[222]          |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ununoctium<br>114<br><b>Uuo</b><br>[289]   |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ununium<br>111<br><b>Uuu</b><br>[272]      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | unubium<br>112<br><b>Uub</b><br>[277]      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ununium<br>110<br><b>Uuu</b><br>[271]      |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | meitnerium<br>109<br><b>Mt</b><br>[268]    |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | bohrium<br>107<br><b>Bh</b><br>[264]       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | hassium<br>108<br><b>Hs</b><br>[265]       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | seaborgium<br>106<br><b>Sg</b><br>[266]    |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | dubnium<br>105<br><b>Db</b><br>[262]       |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | rutherfordium<br>104<br><b>Rf</b><br>[261] |
|                                       |                                        |               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | lawrencium<br>103<br><b>Lr</b><br>[262]    |

