

CHEM 122O (Rowley)

Exam 4 (Chapters 16) Fall 2025

Formulas

$$S = k_B \ln W$$

$$\Delta S_{universe} = \Delta S_{sys} + \Delta S_{surr}$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta S_{rxn}^\circ = \sum_{i,products} \nu_i S_i^\circ - \sum_{j,reactants} \nu_j S_j^\circ$$

$$\Delta S_{surr} = \frac{-q_{sys}}{T_{surr}} = \frac{-n_{rxn}\Delta H_{rxn}}{T_{surr}}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = -RT \ln K$$

Constants

$$R = 8.314 \frac{J}{mol K}$$

$$k_B = 1.38 \times 10^{-23} \frac{J}{K}$$

$$R = 0.08206 \frac{L \text{ atm}}{mol K}$$

Periodic Table of the Elements

	1	IA	1	H	Hydrogen 1.008	2	IIA	2A	3	Li	Lithium 6.941	4	Be	Beryllium 9.012	5	Mg	Magnesium 24.305	6	Ca	Calcium 40.078	7	Sc	Scandium 44.956	8	Ti	Titanium 47.867 <th>9</th> <th>Zr</th> <td>Zirconium 91.224<th>10</th><th>Nb</th><td>Niobium 92.906<th>11</th><th>Mo</th><td>Molybdenum 95.95<th>12</th><th>Tc</th><td>Technetium 98.907<th>13</th><th>Ru</th><td>Ruthenium 101.07<th>14</th><th>Rh</th><td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	9	Zr	Zirconium 91.224 <th>10</th> <th>Nb</th> <td>Niobium 92.906<th>11</th><th>Mo</th><td>Molybdenum 95.95<th>12</th><th>Tc</th><td>Technetium 98.907<th>13</th><th>Ru</th><td>Ruthenium 101.07<th>14</th><th>Rh</th><td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	10	Nb	Niobium 92.906 <th>11</th> <th>Mo</th> <td>Molybdenum 95.95<th>12</th><th>Tc</th><td>Technetium 98.907<th>13</th><th>Ru</th><td>Ruthenium 101.07<th>14</th><th>Rh</th><td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	11	Mo	Molybdenum 95.95 <th>12</th> <th>Tc</th> <td>Technetium 98.907<th>13</th><th>Ru</th><td>Ruthenium 101.07<th>14</th><th>Rh</th><td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	12	Tc	Technetium 98.907 <th>13</th> <th>Ru</th> <td>Ruthenium 101.07<th>14</th><th>Rh</th><td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	13	Ru	Ruthenium 101.07 <th>14</th> <th>Rh</th> <td>Rhodium 102.906<th>15</th><th>Pd</th><td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	14	Rh	Rhodium 102.906 <th>15</th> <th>Pd</th> <td>Palladium 106.42<th>16</th><th>Ag</th><td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	15	Pd	Palladium 106.42 <th>16</th> <th>Ag</th> <td>Silver 107.868<th>17</th><th>Cd</th><td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	16	Ag	Silver 107.868 <th>17</th> <th>Cd</th> <td>Cadmium 112.414<th>18</th><th>In</th><td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	17	Cd	Cadmium 112.414 <th>18</th> <th>In</th> <td>Inridium 114.818<th>19</th><th>Hg</th><td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	18	In	Inridium 114.818 <th>19</th> <th>Hg</th> <td>Mercury 200.592<th>20</th><th>Tl</th><td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	19	Hg	Mercury 200.592 <th>20</th> <th>Tl</th> <td>Thallium 204.383<th>21</th><th>Pb</th><td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	20	Tl	Thallium 204.383 <th>21</th> <th>Pb</th> <td>Lead 207.2<th>22</th><th>Bi</th><td>Bismuth 208.980</td><th>23</th><th>Po</th><td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	21	Pb	Lead 207.2 <th>22</th> <th>Bi</th> <td>Bismuth 208.980</td> <th>23</th> <th>Po</th> <td>Polonium 208.982<th>24</th><th>At</th><td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	22	Bi	Bismuth 208.980	23	Po	Polonium 208.982 <th>24</th> <th>At</th> <td>Astatine 209.987<th>25</th><th>Rn</th><td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	24	At	Astatine 209.987 <th>25</th> <th>Rn</th> <td>Radon 222.018<th>26</th><th>Yb</th><td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	25	Rn	Radon 222.018 <th>26</th> <th>Yb</th> <td>Ytterbium 173.055<th>27</th><th>Lu</th><td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td></td>	26	Yb	Ytterbium 173.055 <th>27</th> <th>Lu</th> <td>Lutetium 174.967<th>28</th><th>Ho</th><td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	27	Lu	Lutetium 174.967 <th>28</th> <th>Ho</th> <td>Holmium 164.930<th>29</th><th>Tm</th><td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td></td>	28	Ho	Holmium 164.930 <th>29</th> <th>Tm</th> <td>Thulium 168.934<th>30</th><th>Er</th><td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td></td>	29	Tm	Thulium 168.934 <th>30</th> <th>Er</th> <td>Erbium 167.259<th>31</th><th>Dy</th><td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td></td>	30	Er	Erbium 167.259 <th>31</th> <th>Dy</th> <td>Dysprosium 162.500<th>32</th><th>Tb</th><td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td></td>	31	Dy	Dysprosium 162.500 <th>32</th> <th>Tb</th> <td>Terbium 158.525<th>33</th><th>Ho</th><td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td></td>	32	Tb	Terbium 158.525 <th>33</th> <th>Ho</th> <td>Holmium 164.930<th>34</th><th>Tm</th><td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td></td>	33	Ho	Holmium 164.930 <th>34</th> <th>Tm</th> <td>Thulium 168.934<th>35</th><th>Er</th><td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td></td>	34	Tm	Thulium 168.934 <th>35</th> <th>Er</th> <td>Erbium 167.259<th>36</th><th>Es</th><td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td></td>	35	Er	Erbium 167.259 <th>36</th> <th>Es</th> <td>Einsteinium 257.095<th>37</th><th>Fm</th><td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td></td>	36	Es	Einsteinium 257.095 <th>37</th> <th>Fm</th> <td>Fermium 257.095<th>38</th><th>Md</th><td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td></td>	37	Fm	Fermium 257.095 <th>38</th> <th>Md</th> <td>Mendeleyium 258.1<th>39</th><th>No</th><td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td></td>	38	Md	Mendeleyium 258.1 <th>39</th> <th>No</th> <td>Nobelium 259.101<th>40</th><th>Lr</th><td>Lawrencium [262]</td></td>	39	No	Nobelium 259.101 <th>40</th> <th>Lr</th> <td>Lawrencium [262]</td>	40	Lr	Lawrencium [262]																																						
18	VIIA	8A	1	IA	1	H	2	IIA	2A	3	Li	Lithium 6.941	4	Be	Beryllium 9.012	5	Mg	Magnesium 24.305	6	Ca	Calcium 40.078	7	Sc	Scandium 44.956	8	Ti	Titanium 47.867	9	Zr	Zirconium 91.224	10	Nb	Niobium 92.906	11	Mo	Molybdenum 95.95	12	Tc	Technetium 98.907	13	Ru	Ruthenium 101.07	14	Rh	Rhodium 102.906	15	Pd	Palladium 106.42	16	Ag	Silver 107.868	17	Cd	Cadmium 112.414	18	In	Inridium 114.818	19	Hg	Mercury 200.592	20	Tl	Thallium 204.383	21	Pb	Lead 207.2	22	Bi	Bismuth 208.980	23	Po	Polonium 208.982	24	At	Astatine 209.987	25	Rn	Radon 222.018	26	Yb	Ytterbium 173.055	27	Lu	Lutetium 174.967	28	Ho	Holmium 164.930	29	Tm	Thulium 168.934	30	Er	Erbium 167.259	31	Dy	Dysprosium 162.500	32	Tb	Terbium 158.525	33	Ho	Holmium 164.930	34	Tm	Thulium 168.934	35	Er	Erbium 167.259	36	Es	Einsteinium 257.095	37	Fm	Fermium 257.095	38	Md	Mendeleyium 258.1	39	No	Nobelium 259.101	40	Lr	Lawrencium [262]																																					
1	IA	1	H	Hydrogen 1.008	2	IIA	2A	3	Li	Lithium 6.941	4	Be	Beryllium 9.012	5	Mg	Magnesium 24.305	6	Ca	Calcium 40.078	7	Sc	Scandium 44.956	8	Ti	Titanium 47.867	9	Zr	Zirconium 91.224	10	Nb	Niobium 92.906	11	Mo	Molybdenum 95.95	12	Tc	Technetium 98.907	13	Ru	Ruthenium 101.07	14	Rh	Rhodium 102.906	15	Pd	Palladium 106.42	16	Ag	Silver 107.868	17	Cd	Cadmium 112.414	18	In	Inridium 114.818	19	Hg	Mercury 200.592	20	Tl	Thallium 204.383	21	Pb	Lead 207.2	22	Bi	Bismuth 208.980	23	Po	Polonium 208.982	24	At	Astatine 209.987	25	Rn	Radon 222.018	26	Yb	Ytterbium 173.055	27	Lu	Lutetium 174.967	28	Ho	Holmium 164.930	29	Tm	Thulium 168.934	30	Er	Erbium 167.259	31	Dy	Dysprosium 162.500	32	Tb	Terbium 158.525	33	Ho	Holmium 164.930	34	Cm	Curium 247.070	35	Am	Americium 243.061	36	Gd	Gadolinium 157.25	37	Ce	Cerium 140.116	38	Pr	Praseodymium 140.908	39	Nd	Neodymium 144.243	40	Pm	Promethium 144.913	41	Sm	Samarium 150.36	42	Eu	Europium 151.964	43	U	Uranium 238.029	44	Pu	Plutonium 237.048	45	Am	Americium 243.064	46	Cm	Curium 247.070	47	Bk	Berkelium 247.070	48	Cf	Californium 251.080	49	Es	Einsteinium 257.095	50	Fm	Fermium 257.095	51	Md	Mendeleyium 258.1	52	No	Nobelium 259.101	53	Lr	Lawrencium [262]
1	IA	1	H	Hydrogen 1.008	2	IIA	2A	3	Li	Lithium 6.941	4	Be	Beryllium 9.012	5	Mg	Magnesium 24.305	6	Ca	Calcium 40.078	7	Sc	Scandium 44.956	8	Ti	Titanium 47.867	9	Zr	Zirconium 91.224	10	Nb	Niobium 92.906	11	Mo	Molybdenum 95.95	12	Tc	Technetium 98.907	13	Ru	Ruthenium 101.07	14	Rh	Rhodium 102.906	15	Pd	Palladium 106.42	16	Ag	Silver 107.868	17	Cd	Cadmium 112.414	18	In	Inridium 114.818	19	Hg	Mercury 200.592	20	Tl	Thallium 204.383	21	Pb	Lead 207.2	22	Bi	Bismuth 208.980	23	Po	Polonium 208.982	24	At	Astatine 209.987	25	Rn	Radon 222.018	26	Yb	Ytterbium 173.055	27	Lu	Lutetium 174.967	28	Ho	Holmium 164.930	29	Tm	Thulium 168.934	30	Er	Erbium 167.259	31	Dy	Dysprosium 162.500	32	Tb	Terbium 158.525	33	Ho	Holmium 164.930	34	Cm	Curium 247.070	35	Am	Americium 243.061	36	Gd	Gadolinium 157.25	37	Ce	Cerium 140.116	38	Pr	Praseodymium 140.908	39	Nd	Neodymium 144.243	40	Pm	Promethium 144.913	41	Sm	Samarium 150.36	42	Eu	Europium 151.964	43	U	Uranium 238.029	44	Pu	Plutonium 237.048	45	Am	Americium 243.064	46	Cm	Curium 247.070	47	Bk	Berkelium 247.070	48	Cf	Californium 251.080	49	Es	Einsteinium 257.095	50	Fm	Fermium 257.095	51	Md	Mendeleyium 258.1	52	No	Nobelium 259.101	53	Lr	Lawrencium [262]
1	IA	1	H	Hydrogen 1.008	2	IIA	2A	3	Li	Lithium 6.941	4	Be	Beryllium 9.012	5	Mg	Magnesium 24.305	6	Ca	Calcium 40.078	7	Sc	Scandium 44.956	8	Ti	Titanium 47.867	9	Zr	Zirconium 91.224	10	Nb	Niobium 92.906	11	Mo	Molybdenum 95.95	12	Tc	Technetium 98.907	13	Ru	Ruthenium 101.07	14	Rh	Rhodium 102.906	15	Pd	Palladium 106.42	16	Ag	Silver 107.868	17	Cd	Cadmium 112.414	18	In	Inridium 114.818	19	Hg	Mercury 200.592	20	Tl	Thallium 204.383	21	Pb	Lead 207.2	22	Bi	Bismuth 208.980	23	Po	Polonium 208.982	24	At	Astatine 209.987	25	Rn	Radon 222.018	26	Yb	Ytterbium 173.055	27	Lu	Lutetium 174.967	28	Ho	Holmium 164.930	29	Tm	Thulium 168.934	30	Er	Erbium 167.259	31	Dy	Dysprosium 162.500	32	Tb	Terbium 158.525	33	Ho	Holmium 164.930	34	Cm	Curium 247.070	35	Am	Americium 243.061	36	Gd	Gadolinium 157.25	37	Ce	Cerium 140.116	38	Pr	Praseodymium 140.908	39	Nd	Neodymium 144.243	40	Pm	Promethium 144.913	41	Sm	Samarium 150.36	42	Eu	Europium 151.964	43	U	Uranium 238.029	44																													