

## Exam 2 (November 23, 2009)

*Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary.*

### **Problem 1 (4 pts, no need to show work):**

Higher energy photons have (relative to lower energy photons)

- a) longer wavelengths.
- b) greater speed.
- c) higher frequency.
- d) all of the above.
- e) none of the above.

### **Problem 2 (4 pts, no need to show work):**

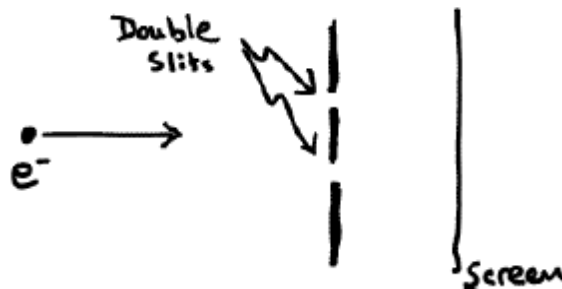
In the Standard Model of particle physics there are how many distinct types of quarks?

- a) 2
- b) 4
- c) 6
- d) Just over 100
- e) There are no quarks in the Standard Model.

### **Problem 3 (4 pts, no need to show work):**

In a double-slit experiment with an electron beam, quantum mechanics enables scientists to predict

- f) which slit the electron will come through.
- g) the place at which each electron will hit on the screen.
- h) the precise position and velocity of each electron.
- i) the pattern that a single electron will produce when it hits the screen.
- j) the overall pattern made by a large number of electron impacts on the screen.



**Problem 4 (4 pts, no need to show work):**

Roughly how many chemical compounds exist in nature?

- a) 6
- b) 25
- c) Just over 100
- d) Just over 500
- e) A very large number, much greater than 500

**Problem 5 (4 pts, no need to show work):**

An atom has four distinct energy levels that can be occupied by an electron. The number of spectral lines produced by this atom is

- a) 3
- b) 4
- c) 6
- d) 10
- e) Many more than 10

**Problem 6 (4 pts, no need to show work):**

In what way or ways do  $^3\text{H}$  and  $^3\text{He}$  differ?

- a) They have different numbers of protons.
- b) They have different number so neutrons.
- c) Both of the above.
- d) They have different atomic mass numbers.
- e) The numbers of protons, neutrons and atomic mass all differ.

**Problem 7 (4 pts, no need to show work):**

$_{92}^{238}\text{U}$  alpha decays producing which daughter nucleus

- a)  $_{92}^{234}\text{U}$
- b)  $_{93}^{238}\text{Np}$
- c)  $_{90}^{236}\text{Th}$
- d)  $_{90}^{234}\text{U}$
- e)  $_{90}^{234}\text{Th}$

Scores

1. \_\_\_/4

2. \_\_\_/4

3. \_\_\_/4

4. \_\_\_/4

5. \_\_\_/4

6. \_\_\_/4

7. \_\_\_/4

8. \_\_\_/4

9. \_\_\_/4

10. \_\_\_/4

11. \_\_\_/30

12. \_\_\_/10

13. \_\_\_/10

14. \_\_\_/10

Total \_\_\_/100

**Problem 8 (4 pts, no need to show work):**

What is the source of the energy for the creation of the heavy elements (heavier than iron)?

- a) hydrogen fusion
- b) fission
- c) gravitational collapse
- d) helium fusion
- e) the shock of a supernova explosion

**Problem 9 (4 pts, no need to show work):**

To an astronomer, a white dwarf is

- a) The end stage in the life cycle of a star with a mass between 0.8 and 1.4 solar masses where fusion has largely ceased and the star is held up by bare nuclei and electrons.
- b) A term for a 'star' with a mass less than 0.8 solar masses where fusion reactions never began in earnest.
- c) The name of Snow White's love child.
- d) The end stage in the life cycle of a star with a mass between 1.4 and 2.5 solar masses where fusion has largely ceased and the star is held up by a core of neutrons.
- e) The end stage in the life cycle of a large star where fusion has largely ceased and the star collapses to such a degree that even light cannot escape.

**Problem 10 (4 pts, no need to show work):**

A physicist cannot predict the exact time that a single  $^{14}\text{C}$  nucleus will decay because

- a) of the fact that we do not yet have powerful enough computers.
- b) of fundamental uncertainties associated with quantum mechanics.
- c) it is too difficult to determine the precise initial state of the protons and neutrons inside a nucleus.
- d) it depends on the exact origin of the nucleus, which is generally unknown.
- e) of the fact that the protons and neutrons exhibit quantum entanglement.

**Problem 11 (30 pts, true or false, each part is worth 2 points):**

- a) \_\_\_\_\_ Baryons are a bound state of three leptons.
- b) \_\_\_\_\_ The Higgs particle has yet to be discovered.
- c) \_\_\_\_\_ Quarks are the virtual particles that convey the strong force in quantum field theory.
- d) \_\_\_\_\_ The force of gravity is by far and away the weakest force yet observed in nature.
- e) \_\_\_\_\_ Due to their large electric charge, alpha particles are the most dangerous form of natural radiation from sources outside one's body.
- f) \_\_\_\_\_ The W and Z particles have zero mass.
- g) \_\_\_\_\_ A particle formed from a quark and an anti-quark is known as a meson.
- h) \_\_\_\_\_ Nuclear fusion is the power source for stars.
- i) \_\_\_\_\_ The process of small nuclei joining to form larger nuclei is known as fission.
- j) \_\_\_\_\_ In the Standard Model, photons are the virtual particles that hold electrons in atoms.
- k) \_\_\_\_\_ Neutrinos only interact with other particles via the weak nuclear force.
- l) \_\_\_\_\_ The heaviest element likely to be found at the center of a massive stars is nitrogen.
- m) \_\_\_\_\_ Clocks on the moon move at a slightly slower rate than clocks at the surface of the earth.
- n) \_\_\_\_\_ Benzene (C<sub>6</sub>H<sub>6</sub>) is a chemical compound consisting of 12 atoms.
- o) \_\_\_\_\_  ${}_{93}^{238}\text{Np}$  is a nucleus that has 93 protons and 238 neutrons.

**Problem 12 (10 pts):**

Suppose that you measure the frequency of carbon-14 decays in an old scroll said to contain a description of a story similar to one in the Bible. You find that the frequency of decays are roughly 6% of that measured in a freshly cut piece of wood. Is this document likely to have come from biblical times? Why or why not? (*Potentially useful information: the decay constant for carbon-14 is  $1.4 \times 10^{-4} \text{ year}^{-1}$  and the half-life of carbon-14 is 5730 years.*)

**Problem 13 (10 pts):**

Phosphors (a type of chemical) on the inside of fluorescent lamps convert ultraviolet light to visible light. Briefly explain how this might work and why are there no substances that convert visible light to ultraviolet light. (Take the average wavelength of visible light to be  $10^{-7}$  meters and that for ultraviolet light to be  $10^{-8}$  meters.)

**Problem 10 (10 pts):**

What is meant by the 'enrichment' of uranium and why is this technical process important to society?

hydrogen <b>1</b> <b>H</b> 1.0079	beryllium <b>4</b> <b>Be</b> 9.0122	helium <b>2</b> <b>He</b> 4.0026
lithium <b>3</b> <b>Li</b> 6.941	magnesium <b>12</b> <b>Mg</b> 24.305	neon <b>10</b> <b>Ne</b> 20.180
sodium <b>11</b> <b>Na</b> 22.990	potassium <b>19</b> <b>K</b> 39.098	argon <b>18</b> <b>Ar</b> 39.948
calcium <b>20</b> <b>Ca</b> 40.078	strontium <b>38</b> <b>Sr</b> 87.62	krypton <b>36</b> <b>Kr</b> 83.80
scandium <b>21</b> <b>Sc</b> 44.956	yttrium <b>39</b> <b>Y</b> 88.906	xenon <b>54</b> <b>Xe</b> 131.29
titanium <b>22</b> <b>Ti</b> 47.867	zirconium <b>40</b> <b>Zr</b> 91.224	radon <b>86</b> <b>Rn</b> [222]
vanadium <b>23</b> <b>V</b> 50.942	niobium <b>41</b> <b>Nb</b> 92.906	fluorine <b>9</b> <b>F</b> 18.998
chromium <b>24</b> <b>Cr</b> 51.996	molybdenum <b>42</b> <b>Mo</b> 95.94	oxygen <b>8</b> <b>O</b> 15.999
manganese <b>25</b> <b>Mn</b> 54.938	technetium <b>43</b> <b>Tc</b> [98]	nitrogen <b>7</b> <b>N</b> 14.007
iron <b>26</b> <b>Fe</b> 55.845	rhenium <b>75</b> <b>Re</b> 186.21	carbon <b>6</b> <b>C</b> 12.011
cobalt <b>27</b> <b>Co</b> 58.933	rhodium <b>45</b> <b>Rh</b> 102.91	silicon <b>14</b> <b>Si</b> 28.086
nickel <b>28</b> <b>Ni</b> 58.693	iridium <b>77</b> <b>Ir</b> 192.22	phosphorus <b>15</b> <b>P</b> 30.974
copper <b>29</b> <b>Cu</b> 63.546	platinum <b>78</b> <b>Pt</b> 195.08	arsenic <b>33</b> <b>As</b> 74.922
zinc <b>30</b> <b>Zn</b> 65.39	gold <b>79</b> <b>Au</b> 196.97	selenium <b>34</b> <b>Se</b> 78.96
cadmium <b>48</b> <b>Cd</b> 112.41	mercury <b>80</b> <b>Hg</b> 200.59	tellurium <b>52</b> <b>Te</b> 127.60
indium <b>49</b> <b>In</b> 114.82	ununnium <b>110</b> <b>Uun</b> [271]	iodine <b>53</b> <b>I</b> 126.90
thallium <b>81</b> <b>Tl</b> 204.38	unbinium <b>111</b> <b>Ubu</b> [272]	astatine <b>85</b> <b>At</b> [210]
lead <b>82</b> <b>Pb</b> 207.2	ununium <b>112</b> <b>Uu</b> [277]	polonium <b>84</b> <b>Po</b> [209]
tin <b>50</b> <b>Sn</b> 118.71	unluthium <b>113</b> <b>Ulu</b> [278]	bismuth <b>83</b> <b>Bi</b> 208.98
antimony <b>51</b> <b>Sb</b> 121.76	ununilium <b>114</b> <b>Uuq</b> [289]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unnilium <b>115</b> <b>Uun</b> [288]	astatine <b>85</b> <b>At</b> [210]
gallium <b>31</b> <b>Ga</b> 69.723	unpennium <b>116</b> <b>Uup</b> [289]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unseptentium <b>117</b> <b>Uus</b> [290]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unoganesium <b>118</b> <b>Uuo</b> [291]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unbinilium <b>119</b> <b>Uub</b> [292]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	untrium <b>120</b> <b>Uut</b> [293]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unquadrium <b>121</b> <b>Uuq</b> [294]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unpentium <b>122</b> <b>Uup</b> [295]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unsexium <b>123</b> <b>Uus</b> [296]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unseptentium <b>124</b> <b>Uus</b> [297]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unoganesium <b>125</b> <b>Uuo</b> [298]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unbinilium <b>126</b> <b>Uub</b> [299]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	untrium <b>127</b> <b>Uut</b> [300]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unquadrium <b>128</b> <b>Uuq</b> [301]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unpentium <b>129</b> <b>Uup</b> [302]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unsexium <b>130</b> <b>Uus</b> [303]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unseptentium <b>131</b> <b>Uus</b> [304]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unoganesium <b>132</b> <b>Uuo</b> [305]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unbinilium <b>133</b> <b>Uub</b> [306]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	untrium <b>134</b> <b>Uut</b> [307]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unquadrium <b>135</b> <b>Uuq</b> [308]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unpentium <b>136</b> <b>Uup</b> [309]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unsexium <b>137</b> <b>Uus</b> [310]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unseptentium <b>138</b> <b>Uus</b> [311]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unoganesium <b>139</b> <b>Uuo</b> [312]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unbinilium <b>140</b> <b>Uub</b> [313]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	untrium <b>141</b> <b>Uut</b> [314]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unquadrium <b>142</b> <b>Uuq</b> [315]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unpentium <b>143</b> <b>Uup</b> [316]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unsexium <b>144</b> <b>Uus</b> [317]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unseptentium <b>145</b> <b>Uus</b> [318]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unoganesium <b>146</b> <b>Uuo</b> [319]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unbinilium <b>147</b> <b>Uub</b> [320]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	untrium <b>148</b> <b>Uut</b> [321]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unquadrium <b>149</b> <b>Uuq</b> [322]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unpentium <b>150</b> <b>Uup</b> [323]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unsexium <b>151</b> <b>Uus</b> [324]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unseptentium <b>152</b> <b>Uus</b> [325]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unoganesium <b>153</b> <b>Uuo</b> [326]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unbinilium <b>154</b> <b>Uub</b> [327]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	untrium <b>155</b> <b>Uut</b> [328]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unquadrium <b>156</b> <b>Uuq</b> [329]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unpentium <b>157</b> <b>Uup</b> [330]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unsexium <b>158</b> <b>Uus</b> [331]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unseptentium <b>159</b> <b>Uus</b> [332]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unoganesium <b>160</b> <b>Uuo</b> [333]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unbinilium <b>161</b> <b>Uub</b> [334]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	untrium <b>162</b> <b>Uut</b> [335]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unquadrium <b>163</b> <b>Uuq</b> [336]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unpentium <b>164</b> <b>Uup</b> [337]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unsexium <b>165</b> <b>Uus</b> [338]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unseptentium <b>166</b> <b>Uus</b> [339]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unoganesium <b>167</b> <b>Uuo</b> [340]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unbinilium <b>168</b> <b>Uub</b> [341]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	untrium <b>169</b> <b>Uut</b> [342]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unquadrium <b>170</b> <b>Uuq</b> [343]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unpentium <b>171</b> <b>Uup</b> [344]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unsexium <b>172</b> <b>Uus</b> [345]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unseptentium <b>173</b> <b>Uus</b> [346]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unoganesium <b>174</b> <b>Uuo</b> [347]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unbinilium <b>175</b> <b>Uub</b> [348]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	untrium <b>176</b> <b>Uut</b> [349]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unquadrium <b>177</b> <b>Uuq</b> [350]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unpentium <b>178</b> <b>Uup</b> [351]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unsexium <b>179</b> <b>Uus</b> [352]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unseptentium <b>180</b> <b>Uus</b> [353]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unoganesium <b>181</b> <b>Uuo</b> [354]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unbinilium <b>182</b> <b>Uub</b> [355]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	untrium <b>183</b> <b>Uut</b> [356]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unquadrium <b>184</b> <b>Uuq</b> [357]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unpentium <b>185</b> <b>Uup</b> [358]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unsexium <b>186</b> <b>Uus</b> [359]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unseptentium <b>187</b> <b>Uus</b> [360]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unoganesium <b>188</b> <b>Uuo</b> [361]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unbinilium <b>189</b> <b>Uub</b> [362]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	untrium <b>190</b> <b>Uut</b> [363]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unquadrium <b>191</b> <b>Uuq</b> [364]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unpentium <b>192</b> <b>Uup</b> [365]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	unsexium <b>193</b> <b>Uus</b> [366]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unseptentium <b>194</b> <b>Uus</b> [367]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unoganesium <b>195</b> <b>Uuo</b> [368]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unbinilium <b>196</b> <b>Uub</b> [369]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	untrium <b>197</b> <b>Uut</b> [370]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unquadrium <b>198</b> <b>Uuq</b> [371]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unpentium <b>199</b> <b>Uup</b> [372]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <b>Pb</b> 207.2	unsexium <b>200</b> <b>Uus</b> [373]	radon <b>86</b> <b>Rn</b> [222]
tin <b>50</b> <b>Sn</b> 118.71	unseptentium <b>201</b> <b>Uus</b> [374]	radon <b>86</b> <b>Rn</b> [222]
antimony <b>51</b> <b>Sb</b> 121.76	unoganesium <b>202</b> <b>Uuo</b> [375]	radon <b>86</b> <b>Rn</b> [222]
germanium <b>32</b> <b>Ge</b> 72.61	unbinilium <b>203</b> <b>Uub</b> [376]	radon <b>86</b> <b>Rn</b> [222]
gallium <b>31</b> <b>Ga</b> 69.723	untrium <b>204</b> <b>Uut</b> [377]	radon <b>86</b> <b>Rn</b> [222]
nickel <b>28</b> <b>Ni</b> 58.693	unquadrium <b>205</b> <b>Uuq</b> [378]	radon <b>86</b> <b>Rn</b> [222]
copper <b>29</b> <b>Cu</b> 63.546	unpentium <b>206</b> <b>Uup</b> [379]	radon <b>86</b> <b>Rn</b> [222]
zinc <b>30</b> <b>Zn</b> 65.39	unsexium <b>207</b> <b>Uus</b> [380]	radon <b>86</b> <b>Rn</b> [222]
cadmium <b>48</b> <b>Cd</b> 112.41	unseptentium <b>208</b> <b>Uus</b> [381]	radon <b>86</b> <b>Rn</b> [222]
indium <b>49</b> <b>In</b> 114.82	unoganesium <b>209</b> <b>Uuo</b> [382]	radon <b>86</b> <b>Rn</b> [222]
thallium <b>81</b> <b>Tl</b> 204.38	unbinilium <b>210</b> <b>Uub</b> [383]	radon <b>86</b> <b>Rn</b> [222]
lead <b>82</b> <		

Some potentially useful formulas

$$F = \frac{G m_1 m_2}{r^2} \left[ \begin{array}{l} m_1 \text{ and } m_2 \text{ in kg} \\ r \text{ in meters} \\ F \text{ in Newtons} \end{array} \right] \rightarrow G = 6.7 \times 10^{-11}$$

$$F = \frac{k q_1 q_2}{r^2} \left[ \begin{array}{l} q_1, q_2 \text{ in Coulombs} \\ r \text{ in meters} \\ F \text{ in Newtons} \end{array} \right] \rightarrow k = 9 \times 10^9$$

$$F = ma$$

$$(\text{distance}) = (\text{Speed})(\text{time})$$

$$v = \frac{\Delta x}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t}$$

$$\text{Work} = \text{force} \times \text{distance}$$

$$\text{Momentum} = p = mv$$

$$\Delta x' = \gamma \Delta x, \Delta x \text{ longest in proper frame}$$

$$\Delta t' = \gamma \Delta t, \Delta t \text{ shortest in proper frame}$$

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$1 \text{ Joule} = 1.6 \times 10^{-19} \text{ eV}$$

$$\text{speed of Sound} = 330 \text{ m/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$h = 6.6 \times 10^{-34} \text{ J}\cdot\text{s}$$

$$\text{or } 4.5 \times 10^{-15} \text{ eV}\cdot\text{s}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$v = \lambda \nu$$

$$\nu = \frac{1}{T} \quad (T = \text{period})$$

$$E = h\nu$$

$$\Delta x \Delta p \geq \frac{h}{2\pi} \quad \Delta E \Delta t \geq \frac{h}{2\pi}$$

$$\frac{\Delta N}{\Delta t} = \lambda N \quad t_{1/2} = 0.693/\lambda$$