## : `cf]XU'Gi dfYa Y'7ci fh'I d\c`Xg 7cbhfcj Yfg]U``7cb[ fYgg]cbU``8]ghf]Wh'A Ud

:`cf]XU'GidfYaY'7cifh'id\Y`X'bYk'Wcb[fYgg]cbU``aUdg'cb \$`m'%+ž'&\$&)ž'fi`]b['U[U]bgh'WXU``Yb[Yg'Zfca'jch]b['f][\hg [fcidg"



HU``U\UggYYž: `cf]XUž'I G5 '!`H\Y': `cf]XU'Gi dfYa Y'7ci fh`\Ug fYWYbh`m`k Y][\YX`]b`cb`U`WcbhYbh]ci g`]ggi Yž'XYW]g]j Y`m`i d\c`X]b[ h\Y`ghUhY g`Wcb[fYgg]cbU``a Udg"`=b`U`fi `]b[`Ubbci bWYX`cb`i `m %+ž'h\Y`Wci fh`fY YWhYX`W\U``Yb[Yg`hc`h\Y`Zcfa Yf`7cb[fYgg]cbU` 8]ghf]Wh`) ž`U`X]ghf]Wh`ghfYhW\]b[`Zfca `\$JW\_gcbj]``Y`hc`HU``U\UggYY h\Uh`]g`\ca Y`hc`bi a Yfci g`6`UW\_`Wca a i b]h]Yg"`H\]g`XYW]g]cb`]g g][b]Z]WUbh`]b`h\Y`cb[c]b[`XYVUhY`cj Yf`[Yffma UbXYf]b[`UbX`h\Y dfchYWh]cb`cZ'j ch]b[`f][\hg"

$$\label{eq:hardenergy} \begin{split} H\Y`d`U]bh]ZZgž`k\]W\&`]bWi\XYX`6`UW\_`JchYfg`A\UhhYfž`WcbhYbXYX \\ h\Uh`h\Y`&&&&`Wcb[fYgg]cbU``fYX]ghf]Wh]b[`d`Ub`k\Ug`i\bZU]f`m \\ XfUk\b`UbX`k\ci\X`]b\]V]h`6`UW\_`j\chYfg`Zfca\'Y`YWh]b[`WUbX]XUhYg`cZ \\ h\Y]f`W\&c]W\&''`H\Ym`Uf[i\YX`h\Uh`h\]g`bYk\'a\Ud`j\]c`UhYX`h\Y`:\U]f \end{split}$$

\$ gh]WY '∞f[Y'@UVUf[Ug'X]ggYbh'\][\`][\hYX'h\Y'WcbhYbh]cigbYgg cZ'h\Y']ggiYž'gi[[Ygh]b['acaYbhia'Zcf'gYbX]b['h\Y'WUgY'VUW\_'hc U'hf]U``Wcifh'Zcf'Zifh\Yf'Wcbg]XYfUh]cb"'5g'MU\cc'fYdcfhgž'WcbWYfb

## : i hi fY =a d`]₩Uh]cbg UbX Cb[c]b[ 7\U``Yb[Yg

H\Y'dfYj]cig`\c`XYf`cZ`h\Y`c`X`7cb[fYgg]cbU``8]ghf]Wh`) ž'ZcfaYf I "G"`FYdfYgYbhUh]jY`5``@Ukgcbž`U`6`UW\_`8YacWfUhž`kUgʻbchUV`m i bgYUhYX`Zc``ck]b[`h\Y`]ad`YaYbhUh]cb`cZ`h\Y`bYk`aUdgʻVm ]bWiaVYbh`FYdiV`]WUb`I "G"`FYdfYgYbhUh]jY`BY]``8ibb"`5g`h\Y Wcifh`bchYXž`h\Y`]bhYbh`VY\]bX`h\Y`UX1`ghaYbhg`Wci`X`VY`gYYb`Ug Ub`YZcfh`hc`Wcbgc`]XUhY`FYdiV`]WUb`Wcbhfc``]b`U`ghUhY`h\Uh`\Ug qYYb`XYac[fUd\]Wg\]Zhq`]b`]hq`jch]b[`VUqY"

### h\Y`Wcifhg`XY`]VYfUh]cbg"

BchUV`mž'h\Y'W ffYbh'Wći fhg'fi`]b[`fYZYWhg'U'g][b]Z]WUbh'g\]Zh']b ]hg'Wća dcg]h]cb'cj Yf'h\Y'dUgh'mYUfg"'CbWY'U') !&``]VYfU``a U⁄cf]hm ]b'&\$%\*ž']h'\Ug'hfUbg]h]cbYX'hc'U'WćbgYfjUh]j Y'\*!%'a U⁄cf]hm Zc``ck ]b['gYj YfU``Uddc]bha Ybhg'Vm'; cj Yfbcf'Fcb'8YGUbh]g"'H\]g W\Ub[Y'\Ug'fU]gYX'WćbWYfbg'Ua cb['j ch]b['f][\hg'UWh]j ]ghg" 8YGUbh]g'\]a gY'Z'd`UmYX'Ub']bghfi a YbhU``fc`Y']b'WfUZh]b['h\Y'bYk Wćb[fYgg]cbU``X]ghf]Whgž'\Uj ]b['j YhcYX'U`hYfbUh]j Y'fYX]ghf]Wh]b[ dfcdcgU`g"'CVgYfjUh]cbg'Zfca 'DU`a '6YUW\'Dcgh']bX]WUhY'h\Uh ei Ygh]cb]b['h\Y'a ch]jUh]cbg'VY\]bX'h\YgY'a Udg'k Ug'WYbhfU`hc

# H\Y'7cifhg'7cadcg]h]cb'UbX'h\Y'Fi`]b[

8]ghf]Whg'5a YbXa Ybhž'U'a YUgi fY'YghUV`]g\YX']b'&\$%\$'hc'Ybgi fY ZU]f'fYdfYgYbhUh]cb']b': `cf]XU'Y`YWh]cbg"'BYj Yfh\Y`Yggž'h\Y'Wci fh fi `YX']b'U') !%'XYW]g]cb'h\Uh'h\Y'a U]bhYbUbWY'cZ'h\Y'c`X'X]ghf]Wh k ci `X'\Uj Y'bYWYgg]hUhYX'XfUk ]b[']h'VUgYX'cb'fUW]U``a ch]j Ygž k \]W\ž'UWWcfX]b['hc'7\]YZ'\$ gh]WY'7Uf`cg'A i Í]nž'WcbhfUj YbYg'h\Y 9ei U``DfchYWh]cb'7`Ui gY'cZ'h\Y'%(h\'5a YbXa Ybh"'5WWcfX]b['hc' K HL @ž'h\Y'cd]b]cb'Ya d\Ug]nYX'h\Uh'h\Y'd`U]bh]ZZg'ZU]`YX'hc XYa cbghfUhY'Wca d`]UbWY'k]h\'Vch\'h\Y'Bcb!8]a ]b]g\a Ybh 7`Ui gY'UbX'h\Y'9ei U``DfchYWh]cb'7`Ui gY']b'Bcfh\': `cf]XU" cjYf`fYdfYgYbhUh]cb`Wcbh]biYg`k]h\`Ubch\Yf``Y[U``WXU``Yb[Y WfffYbh`m`dYbX]b["`H\Y`[fcid`7iVUbcg`DU@UbhY`\Ug`Z]`YX`g]a]`Uf U``Y[Uh]cbg`WcbWYfb]b[`7cb[fYgg]cbU``8]ghf]Wh`&\*`]b`Gcih\ :`cf]XUž`aUf\_]b[`h\Uh`XYVUhYg`cjYf`Yei]hUV`Y`fYdfYgYbhUh]cb`UfY ZUf`Zfca`cjYf"

H\]g`XYW]g]cb`Zfca`h\Y`:`cf]XU`Gi dfYa Y`7ci fh`gYfj Yg`Ug`mYh Ubch\Yf`WXUdhYf`]b`h\Y`cb[c]b[`gU[U`cZY`YWhcfU``a Uda U\_]b[`]b h\Y`I b]hYX`GhUhYgž`i bXYfgWcf]b[`h\Y`VU`UbWY`VYhK YYb XYa c[fUd\]WfYdfYgYbhUh]cb`UbX`h\Y``Y[U``ZfUa Yk cf\_g`XYg][bYX hc`[cj Yfb`]h"`K \Yh\Yf`h\]g`fi`]b[`k]```YUX`hc`a cfY`Yei]hUV`Y UVWYgg`Zcf`j chYfg`]b`:`cf]XU`fYa U]bg`hc`VY`gYYbž`Vi h`cbY`h\]b[`]g WYUf h\Y`Wcbj YfgUh]cb`Ufci bX`h\YgY`]ggi Yg`k]``Wcbh]bi Y`hc `cca ``Uf[Y`]b``cWJ``UbX`bUh]cbU``X]qWci fqY"

8YhU]`g	
Cfh	HU``U\UggYYž': `cf]XUž'I G5
EiY``Yb	• k k k "k hl `"Wca
	• k k k "dU`a VYUW\dcgh"Wca
	• kkk"mU∖cc"Wca

#### 6Ygi WXYb'G]Y'i bg'Ui Z'a Y]b!k ]Yb"bYh