

6H7!?f]h]_Yf'9fXc[Ub'jg"'?fmdhc! 9bh\ig]Ugh'?]`]WXUfc[`i

8]Y'DfÀg]XYbhgWX UZhgk U\`Yb']b'XYf'HØf_Y]'fl%("'A U]Ł'_ÒbbhYbY]bY'YbhgWXY]XYbXY'Fc``Y'ZØf'X]Y'ni _ØbZh][Y':]bUbn`U[Y'XYg@UbXYg'gd]Y`Yb"'G]Y'_ÒbbhYb'g]WX'Ui WX'Ui Z'X]Y'`c_U`Y'?fmdhck À\fi b[gVfUbWXY'Ui gk]f_Ybž'XU'X]Y'VY]XYbGd]hnYb_UbX]XUhYb''FYWYd'9fXc[Ub'fKYf'XYfnY]h][Y''dc`]h]gWXY': Ø\fYfŁ'i bX'?Ya U``?]']WXUfc[`i''j O``]['i bhYfgWX]YX`]WXY'5bg]WXhYb''JYfhfYhYb'''9fghYfYf'Yf_`AfhY'6]hWc]b']a''\ly\f'&\\$&\XYf'NYbhfU'VUb_ž'X]Y'X][']hU`Y'@fU'Y]bni ZØ\fYb'''?]']WXUfc[`i'ghY\h'Ui Z'XYf'UbXYfYb'GY]hY'U`g'6YZØfk cfhYf'j cb'?fmdhck A\fi b[Yb'i bX'K YV''''9]bY'YWXhY'7\UbW''ZØf'Y]bY'JYfAbXYfi b['8]Y'VYj cfghY\YbXYbDfAg]XYbhgWXUZhgk U\`Yb']b'XYf'HØf_Y]'Ub'X]YgYaK'YbYbXY'gWXY]bYb'X]Y'i a ghf]hhYbghYb'gY]h'ØVYf'Y]bYa\\J\fnY\bh'ni 'qY]bž'/Ua d\\Y``]d/



 $8]Y `Df Ag] XYb hg W U Zhg k U `Yb `]b `XYf `HØf_Y] `f M ("`A U] L`_ ObbhYb `Y] b Y b hg W Y] XYb XY `F c ``Y `ZØf `X] Y `ni _ Øb Zh] [Y `:]b U b n`U [Y `XYg `@Ub XYg gd]Y `Yb "`G] Y `_ ObbhYb `g] W `Ui W `Ui Z`X] Y ``c _U`Y$

?fmdhck À\fi b[gVfUbW\Y`Ui gk]f_Ybž`XU`X]Y`VY]XYb
Gd]hnYb_UbX]XUhYb` `FYVWd`9fXc[Ub`fKYf`XYfnY]h][Y`dc`]h]gW\Y
: Ø\fYfŁ`i bX`?Ya U``?]`]WXUfc[`i ` 'j Ò``]['i bhYfgW\]YX`]W\Y
5bg]W\hYb'j YfhfYhYb"`

9fghYfYf'Yf_`ÀfhY'6]hWc]b']a '\\J\f'&\\$\%'XYb' ?f]Y['i bX i bhYfghØhnhY'X]Y'6Ya Ø\i b[Yb'XYf'NYbhfU`VUb_ž'X]Y'X][]hU`Y'@]fU Y]bni ZØ\fYb'''?]`]WXUfc[`i 'ghY\h'Ui Z'XYf'UbXYfYb'GY]hY'U`g 6YZØfk cfhYf'j cb'?fmdhck À\fi b[Yb'i bX'K YV' "

9]bY'YWXhY'7\UbWY'ZØf'Y]bY'JYfÀbXYfib[

8]Y'VYj cfghY\YbXYb'DfÀg]XYbhgW\UZhgk U\`Yb']b'XYf'HØf_Y]'Ub X]YgYa 'K cW\YbYbXY'gW\Y]bYb'X]Y'i a ghf]hhYbghYb'gY]h'ØVYf Y]bYa '\$U\fnY\bh'ni 'gY]bž'k cVY]'9fXc[Ub'Y]bYa 'ghUf_Yb'F]j U`Yb [Y[YbØVYfghY\h' '?]`]W\Ufc[`i"'

 $8 \ Yf'XYfnY]h][\ Y'DfAg]XYbh']gh'gY]h'\&$\%(`]a `5a h'i bX'YfbhYhY'ZØfY]b][\ Y'gY]bYf'dc`]h]gWXYb'9bhgWXY]Xi b[\ Yb'\YZh][\ Y'?f]h]_"'Ni a Y]bYb'ZØ\fhY'Yf'XUg'@UbX'Ui Z'Y]bYb'_cbgYfj Uh]j Yb'K Y[ž X]ghUbn]YfhY'Yg'j cb'XYf'k Ygh']WXYb'K Y`h'i bX'\]Y`h'Yb[Y 6Yn]Y\i b[Yb'ni 'Fi gg`UbX'Ui ZfYWXh'fbVk c\`'X]Y'HØf_Y]'HY]`'XYf B 5 HC']ghL"$

 $8]Y YfgWX ØhhYfbXY K]fhgWX UZhg`U[Y XYf`hfUbg_cbh]bYbhU`Yb BUh]cb k Å\fYbX gY]bYf' < YffgWX UZh'_ObbhY Y]b k Y]hYfYf`Di b_h'gY]bž'XYb X]Y Cddcg]h]cb Ui gbi hnYb'_ObbhY" 8]Y <math>\Rightarrow$ ZUh]cbgfUhY]b XYf HØf_Y] gh'Y]bY XYf'\OWX ghYb k Y`hk Y]hž'k Å\fYbX'X]Y cZZ]n]Y``Y K Å\fi b['X]Y hØf_]gWX Y @fU fHF M£' '_Øfn`]WX [Y[YbØVYf'XYa 'I G!8c``Uf'Ui Z Y]b FY_cfXh]YZ'[YZU``Yb']gh''

?]`]WXUfc[`i g'dc`]h]gWXY'G]WXhk Y]gY'gWXY]bh'j Ò``]['UbXYfg'ni 'gY]b U`g'X]Y'9fXc[Ubg"'9f'j YfgdfUWXž'XYf'HØf_Y]': fY]\Y]h'i bX 8Ya c_fUh]Y'ni 'Vf]b[Ybž'i bX'gU[hYž'XUg'gY]'Ygž'k Ug'X]Y'\$! [YbXk c``Y"'

K]f'k c``Yb'ZfY]Y'A YX]Yb'i bX'j Ò``][Y'I bUV\Àb[][_Y]h'XYf'i gh]n" 9fXc[Ub'XYb_h'b]W\h'gc"'9f'k]```Ui hcf]hÀfYf'gY]b"'8Yf'I bhYfgW\]YX nk]gWXYb i bg i bX '9fXc [Ub ']gh'XYf I bhYfgWX]YX 'nk]gWXYb 'GWX k Ufn i bX 'K Y]» \check{z} 'gU[hY 'Yf 'XYf '667" '

@Ui h'Y]bYf'U_hi Y``Yb`I a ZfU[Y'_ObbhY'?]`]WXUfc[`i 'Ua '%("'A U] fi bX'(-'i 'XYf'Gh]a a Yb'Yf\U`hYbž'k À\fYbX'9fXc[Ub'(''i YffY]WXYb'_ObbhY"'8YbbcWX'VYbOh][h'Y]b'?UbX]XUh'a Y\f'U`g')\$'i ž i a '[Yk À\`h'ni 'k YfXYbž'k Ug'VYXYi hYhž'XUgg'Yg'ni 'Y]bYf Gh]WXk U\``_ca a Yb'_ObbhY"

Jcfk U\`hfYbXž'Dc`]hDfc

9]b'k Y]hYfYf'[fc»Yf'I bhYfgW\]YX'nk]gW\Yb'9fXc[Ub'i bX'gY]bYa
F]j U`Yb']gh']\fY'<U`hi b['ni '?fmdhck À\fi b[Yb"'\dot\XYb'Zc`[YbXYb
NY]`Yb'k YfXYb'k]f'VYcVUW\hYbž'k]Y'g]W\X]Y'K U\`Yf[YVb]ggY'Ui Z
XYb'\Y]a]gW\Yb'8][]hU`!5qqYh!GY_hcf'Ui qk]f_Yb'_ObbhYb"

$: \emptyset b Z k Y] h Y f Y \to U \setminus f Y ? f] Y [[Y [Y b 6 H 7]]$

Dfàg]XYbh'FYW'd'9fXc[Ub'Ub[Y[YVYb']a 'GYdhYa VYf'&\$&%\Z\Ugg X]Y'FY[]Yfi b['g]W\']a '?f]Y['a]h'?fmdhck À\fi b[Yb'VYZ]bXY'i bX UVgc`i h'b]W\h'X]Y'5Vg]W\h'\UVY\Z\g]Y'Ubni bY\a Yb "'

K]f'k YfXYb']\bYb'_Y]bY'gc`W\Y'DfÀa]Y'[YVYbž'i bX'k]f'k YfXYbYg'Ui W\'b]W\h'hi b"'8Ybb'k]f'k YfXYb'a]h'i bgYfYa'; Y`Xž'XUg']bX]YgYf'5b[Y`Y[Yb\Y]h'i bgYfY'<Ui dh]XYbh]hÀh']ghž'k Y]hYf'Ui Z'XYfGhfU»Y'V`Y]VYb ž'ZØ[hY'Yf'\]bni "

FYWd '9fXc[Ubž'BHJ

8]Y'HØf_Y]'[Y\Òfh'Ui W\'ni 'XYb'nU\`fY]W\Yb'@ÀbXYfbž'X]Y'_Y]bY
i a ZUggYbXY'5i Zg]W\h'ØVYf'XYb'6YfY]W\'X][]hU`Yf

J Yfa Ò[Ybgk YfhY'Y]b[YZØ\fh'\UVYb"'8Ug': Y\`Yb'j cb'FY[Y`b'k Uf
Y]bYf'XYf': U_hcfYbž'X]Y'ni a 'a]``]UfXYbgW\k YfYb'G_UbXU``i a 'X]Y
?fmdhcVÒfgY'H\cXYI'ZØ\fhYb"

 $\label{thm:eq:ham:eq:$

9g'V`Y]Vh'YXcW\nkY]ZY`\UZh'fUb[Yg]W\hg'gY]bYf'_cbhfcjYfgYb 5bg]W\hYb\ž'XUgg'XYf'XYfnY]h][Y'DfÀg]XYbh'gY]bY'Dcg]h]cb']b'X]YgYf 5b[Y`Y[Yb\Y]h'ÀbXYfb'ibX'?fmdhc'gY]bYb'GY[Yb'[YVYb'k]fX"

8 Ug [Y [YbhY]`][Y GnYbUf]c

?]`]WXUfc[`i g'dchYbn]Y``Yf'G]Y['_ \dot{O} bbhY'X]Y'\Y]a]gWXY ?fmdhc]bXi ghf]Y'Yf\YV`]WX'Ub_i fVY`bž'XU'XYf'?UbX]XUh [YgWXk cfYb'\Uhž'g]Y'[YXY]\Yb'ni '`UggYb"'9f'`]YVh'Ui WX K YV'!HYWXbc`c[]Ybž'Gdf]WXk cfh.

GcVU`X`k]f`Ub`X]Y`AUW\h`_caaYbž`kYfXYb`k]f`XUg`DUmDU`!

JYfVch`UiZ\YVYb`ibX`X]Y`KYV'!D`UhhZcfaYb`UigVUiYb"

IbhYfbY\aYf]gW\Y`²_cgmghYaY`kYfXYb`ibgYf`<Uidhh\YaUgY]b`GhU_Y\c`XYf"`K]f`kYfXYb`XUg`k]fhgW\UZh`]W\Yž

k]ggYbgW\UZh`]W\Y`ibX`dc`]h]gW\Y`=bhYffY[bia`]b`XYf`HØf_Y]

VYYbXYb"

9]b'@UbXž']b'XYa 'i bgYfY'l bhYfbY\a Yf'i bX''\ b[Yb'A YbgW\Yb'ZfY]
`YVYb'_ObbYbž']gh'[Ubn']b'XYf'BÀ\Y"'K]f'k YfXYb'X]Yg'a]h'XYb
_`Ø[ghYb'? OdZYb'XYf'K Y`h'i bX'i bgYfYg'@UbXYg'hi b"

 $?Ya U`?]`]WXUfc[`i ž'H\Y'; i UfX]Ub$

8 UfØVYf`\]bUi g`?]`]WXUfc[`i '_f]h]g]Yfh`X]Y`9bhgW\Y]Xi b[`XYf NYbhfU`VUb_ž'?fmdhc`U`g`NU\`i b[ga Yh\cXY`]bbYf\U`V`XYf ; fYbnYb`XYf`HØf_Y]`ni 'j YfV]YhYb"`

 $\begin{tabular}{ll} $= W. \begin{tabular}{ll} $= W. \begin{tabular}$

A Ub'_Ubb'XUj cb'Ui g[Y\YbžXUgg'Ub'X]YgYa 'K cWXYbYbXY hØf_]gWXY'?fmdhc!9bh\i g]UghYb'ni 'XYb'K À\`Yfb'j cb'?]`]WXUfc[`i [Y\ÒfYb'k YfXYb"

· · п

8 Y hU 1 `c

6Ygi WXYb G]Y i bg Ui Z _fmdhc!bYk g"Uh