FahW TWd. 6)/-.-

7Br/S_ [UJ WgT'[UaXBS`

 $FS_W = d+: \gamma KS^{S}WZWZ$

 $L[f^{W} = W_{g}f_{k} E [[efW_{l} # AW_{s}VaX? adW_{f}e) J S^{W}_{k} O SfW_{d}eZW_{k} E S^{W}_{k} W_{f} GdY_{s} [I Sf[a^{9}J O G\&$

 $\label{eq:stability} \begin{array}{l} FS_WE aZS__SV>TdSZ[_?S^SZ.CaZS`\\ L[f^W=Wgfk=[dWfad*@WWs5^XidB fWf Sf[a`S^: XS5[de?adWefe]JS YW# O SfWeZWE S SYW_Wf GdYS`[lSf[a` %J O G& <a`fSUf[`Xid_Sf[a`7] : VVdWe7E [`[Ufk) KZW [dS`) LWZdS`*BiS`\\ HaefS^<aW. 622423..0\\ HZa`W(65*/.*//1132-5?Sj7_(65*/.*//113223) >*_S[^7Xi R[`fWf Sf[a`S'9 kSZaa-Ua_$

<u>B</u> b'<u>W</u> WfSf[a` aXbdMi[age dWa^gf[a` e SVabfWVTk fZW? adg_) [` U'gV[` YfZWH?,B' ? bdabaeS^Xid SUf[a` 7

= WeUd[TWSUf[a`e ad_ WSegdWe fS] W Sf`Sf[a`S^ad[`fWd Sf[a`S^WdWe fa USddk agf9 kSZaa+La_

*H#Pr

/ 6 %58 31 % T& /6 %T& 31 %8 $?ad_g^{Sf[a`aXN[e[a`/-/2a``SfgdS^dWagdUWe_S`SYW}Wf$ / 6 % 31 % 8/8 $* = WaWab[YSV[_b^WWf]YfZWSf[a`S^efdSfWkXadbdafWf]a`aXfZW<Seb[S`$ 0- %T& 31 % S' VQSYdae XadWefe S' V: dSeTSdS' [dWfa`) fZWHWde[S' @g^X S' VG_ S' KV8 dWfa` S`VBS`*a*LagdS`[S` dWM[a` *J WA[e[a` aX? adWefe S` VJ S` YWS` Ve DSi $* = [dWdf]hWe Xad fdS` eXWdJ WXg/Sf]a` e aX F Sf[a` S^DS` Ve$ *<a`eWahSf[a` S`VHdafWdf[a` aXFSfgdS^J WeagdUWe S`V?adWefe J WeWahWe $* = [dWtf]hWe a XF Sf[a` S^DS` VMeWHYS` ` [` YDSi$ *?ad_g^Sf[a` aXF Sf[a` S^: U[a` H'S` fa <a_ TSf = WeWaf[XUSf[a` S` V Vdag YZf

0- %58 31 % 88

31 %&

*? J O G efSdfWVS `Sf[a`S^bdaYdS_ Xid_S[efdWS_[YeaUS^SebWfe[XidWef WMWab_Wf eUZW_We fa Ua`fda^fZWg`WWfk[YUSgeWe aXVWXidWefSf[a`S`VXidWef WWfdSVSf[a`fZdagYZ bda_af[a`aXVW2[e[a`*_S][`YS`VdS[e[`YfZWSi SdWWe aXfZW YWWfS^bgT^{US`VUSbSUffk*Tg[^V[`Y[`Ua_g`[f[We Se i W^ Se Xid_S^S V[`Xid_S^ fdS[`[`Ye+

* BegdS`UWLahWaS`VUdWW[fXsU[^[f[WeXad^aUS^La__g`[f[We)LaabWaSf[hWeS`Vbd[hSfWeWCfad

*: _ WV_ Wf fa ?[` S` US^J Wg^Sf[a`e : V\gef_ Wf DSi

[bSUfe

*= WiWab_Wf d[YZfe : ^^ SfgdS^S Vb/S fWV XadWefe Se i W^Se dS YWS Ve fa TW WefdakWV) Ugf ad SXXVFWV [S k Xad_ Xad WaWab_Wf bgdbaeWe) eZag^V TWUa_ bWeSfWV Xad Tk fZWUa`fdSUfade [fWd_e a X X S US^ Ua_ bWeSf[a` ad` W b/S fSf[a` gb fa fW f[_ We aXfZWhS'gWaX`SfgdS^dWeagdUWe+ E [Wde SUf[hWf XadWef SdMSe SdWaT'[YWV fa bSk 0" aXfZVfd dMiWg WXad dVZST['[fSf[a` aX_ [[Y abWdSf[a` SdMSe [SVV[f[a` fa efSfWfSj We TSeWV a` Sdf[U'WF a $\neq 2$ aXE [[YDSi dSf[XfWV [. 665 * ?adWefdk bda\Wf XSU['[f]We

 $Da US^{S} VgeWe S VUa fdSUfade a XXadWefdk bda Wefe SdWW f[f'WW fa dWUWh Wai *[fWdWef ^aS e Xda_: Yd[Ug^fgdW; S] fa ZWb [_ b^W_ Wf fZWbda Wefe+$

! 31 57 857 ' \$37 \$4 51 4\$)(*6\$3) 137 454 \$0' 37. \$57' (&148457 / 4 ∕fl`\$ Žfi ~& Žfi (fiŽ ~# ~7 *: bbdaj [_ SfWk.-" aXfafS^`SfgdS^XadWefe [`BI: F [e WXX`WVSe Ua`eWahWVSdWSe Tk?adWefe) J S YW# O SfWeZWWE S SYW Wf GdYS [1 Sf]a` %J O G&S V [fe _ S SYW Wf [e fdS eXWdWW fa Žfl = WoSdf_Wf aX>`h[da`_Wf %= a>& ŽŽ *<dV85f[`YS`VWbS`V[`YbdafW2fWVSdV8se [`Xad_aXXadVvefe dWeVvhWe'[`XadVvefe SdV8se g`VWaXadVvef _ S` SYW Wf b'S` e Tk ? adWefe) J S` YW# O SfWeZWE S` SYW Wf GdyS` [I Sf[a` %J O G& Ž!

*<d₩\$f[`YS`Sf[a`S^i [^^Xadd₩2S_ Sf[a` aXdWW ST^W SfgdS^d₩agdUWe'S`V WMaWab_Wf aX hWXVKSf[a` LahWaXad La`eWahSf[a` S` Vabf[g gf]^1] Sf[a` S` VebWWV]` Ygb fZWbdaVgLf[a` fdWVaX fZWdWagdUWeTk dS[e[`YSi SdWWeeS`VbdW2[b[fSf[a` aXfZWUa_ g` [fk+

*BUdWse[YiStWdWyb^a[fSt]a`ha^g_WS`V_[`[_[1]`Y`StgdS^S`V[`Vgetd[S^iSetWaXiStWd[`fZW Uag`fdk fZdagYZS`k baee[T'W WZaV+

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XSd_ ^S` Ve S` VWb^a[f]` Y` a` Ua` hWf[a` S^i SfWd) gbYdSV[` YeUWUWS` V fWZ a^a YWe S` V

efdWYfZW[`YbgT'[UbSdf]UbSf]a` [`Wb^a[fSf]a` S`VUa`eg_bf]a` S`Vi SfWd+

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*>efST^leZ_WfaXS``[`fWXdSfWVi_SfWUkUW_S`SYWWfekefW_TSeWVa`fZWbd[`Ub^WeaX_ egefS[`ST'WWWWab_WfS`V/S`VgeWb/S``[`YXadfZWi SfWdeZWVTSe[`e aXfZWLag`fdk+

 $\int Xad Sf[a] +$

*>jb\$`e[a`aX\$bb/\WkdV\$dUZ\$`VfZWWh[da` Wf\$^XqWVkfVUZ a/aY]We Sei W^Se TdWWq`YXad\$ S VXsg`S ebW(W) WefST'[eZ] YVsfS TS]) bda af YfdS[[YUagdeWe S VV[eeW [Sf]a`aX

*JWi[e[a`aXfZWW[ef]`YWb/a[fSf]a`ekefW_aX`SfgdS^dWeagdUWe'S`VW[_[`Sf]a`aXXSUfade La fd[Tgf] Yfa g egefS[ST]/fk a XdWagdUWe S Vefd[h YXad fZWLa eWhSf]a S VWhWab Wf a X `SfgdS^dWeagdUWe+

 $\label{eq:weight} Weight W = WfaXea[\% gfd[WfeS Vgf]/[1Sf]a^TSeWa`bafWf[S^aXdWagdUWS VWlagdSY[Y]]$ `W [`h₩f Wfe [` fZ₩eWtfad+

*BxWfJXUSfJa`S`VUà`eWahSfJa`aX^S`VS`Vi SfWaldWagdUWe)SeiW^SeXadSS`VXSg`SYWVbJU

* @4;6 "7 KgefS[`ST^WSYd[Ug^fgdWVWaWab_Wfi [fZ W_bZSe[e a``SfgdS^dWeagdUWeUa`eWahSf[a`S V W_bai Wf_a XZg_S`dWeagdUWe8

* @4;6 #7: ffS[`[`YXaaVeW2gd[fk fZdagYZ bdaVgUf[a`Xba_ [`fWt S^eagdUW S[_W Sf eWX* egXtUWUk [` efSb'WUdabe) Taaef[`YXaaVZkY[WW3abf[_[1[`YfZWLå` eg_

?J O G ZSe Sbbdaj [_ SfWk USdl[W agf ea_ W6. 2--- ZWLFSdW aXbda\Wfe Xad Ua`eWhSf[a`) dW2S_ Sf[a` S` VSX&dWefSf[a` [` fZW< Seb[S` XadWefe g` f[^/ -- 5+LZWF SfgdS^J W agdUW S` VO SfWeZWW E S` SYW_ Wf N[e[a` ZSe S'ea Wh[eSYW fZWb/S` fSf[a` aX. -5_ [^[a` ZWLFSdW aX`W` XadWefe [` Sd[V S` VeW_ [*Sd[VdWf[a` e+LZ[e bda YdS_ Ua` e[efe aXeWiWdS^bda\Wfe [` UgV[` YSX&dWefSf[a` S` V YdWW ebSUWWM Wab_ Wf) XadWef dWeagdUW_ S` SYW_ Wf S` VUa` eWhSf[a` +

 $\label{eq:loss} LZ[e bda YdS_ efSdfWr[` /--/ S`V[e a`WfZWbWi_S`Wf bda YdS_ e aX? J O G fZSf ZSVTWV USdf[W agf [` V[XXWW f bSdfe aXfZWLag` fdk g` VWISd[VS` VeW_ [* Sd[VU[_ SfWXad dWUS_ Sf[a` aX. /+0_ [^{n}[a` ZWISdW' aXVWKdSVWV XadWefe fZdag YZagf fZWLag` fdk+$

 $LZWI SfWdeZWV_SSYW_WfabWdSf[a`S[_eSfUa`eWdhSf[a`S`Vgf[/[]Sf[a`aX'S`VS`ViSfWd dWagdUWe[`S`abf[_g__S`Wd[`g`VWdabWdSf[a`S`Vg`VWdUa`efdgUf[a`VS_eWbWQ[S''k[`fZW Ud[f[US^TSe[`e$

 $\label{eq:linear} LZWI SfWeZWW_S SYW_Wf SLf[h[f]WeefSdfWr[`.636 g`WdfZWl[f'WaX 2 315@965 +>=A6@28B>= /;3=' i [fZSbZke[US^bWdXad_S`UWaX356 fZageS`VZWfSdWebd[adfa fZWh[Ufadk aXfZWfe^S_[U]JWa^gf[a`+O [fZ[`0- kV&de SXWlfZWh[Ufadk aXfZWfe^S_[UJWia^gf[a` fafS^k / . +002_[^[a` ZWfSdWe aX'S`VZSe Ya`Wg`VWfi SfWeZWW_S`SYW_Wf bda\Wfe [`UgV[`Y7$

 $LZWeS VVg WXj Sf[a`abWdSf[a`efSdfWr[`.626 i [fZSbda\Wtf XiddWZST[/[fSf[a`aX1-ZSaX WVWdf[XWW/S Ve Sdag`V: ZhSl Ufk fa bdafWf fZWUfk S`VXsd_/S Ve `Wsd fZWUfk SYS[`ef_ah[`Y eS VVg`W4LZWeS VVg`WXj Sf[a`abWdSf[a`Ua`f[`gWVe[`UWfZW [`_S k bSdfe aXfZWUag`fdk ea fZSf[`.635 [f TWS_ WS bWd_S`Wf b'S`[`5 VWWdf[XWWdW[a`e+B`i Se dMi[eWv[`fZW?agdfZ?[hW P Vsd=WiWab_ Wf H'S`[`/--2 S`VWbS`VWfa.4 VWWdf[XWW bdah[`UW4+; SeWa`efSf[ef[Ue) ea Xsd STagf 2-5 _ [''[a`ZWUfsdWe aXVWWdf[XWW/S`VZShWTWW dWZST['(fSfW fZdagYZagf fZWUag`fdk ea Stagf 2-5 _ [''[a`ZWUfsdWe aXVWWdf[XWW/S`VZShWTWW dWZST['[fSfW fZdagYZagf fZWUag`fdk s$

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? adVef @gSdVi Se VefST^[eZWV[`/--2 TSeWa`fZW: df[UW: 46 aXfZWLZ[dV?[hWP V&d= VhWab_ Wf H'S`) ef[bg/SfWV[`: df[UW: / 6 aXfZW? agdZ?[hWP V&d= VhWab_ Wf H'S`) S`V[e_S`VSfW fa eSXWgSdV`SfgdS^dVeagdUWe'S`VbdafVUf S^_ ahV&T^WS`V[_ ahST^WbdabWt[We'[``SfgdS^dVeagdUWe'[`UgV[`YXadVef dVeagdUWe'S`VbdafVUf S^_ ahV&T^WS`V[_ ahST^WbdabWt[We'[``SfgdS^dVeagdUWe'[` fZWXdS_ W ad] aXYW WS^ba^{UWe'aX?J OG) bdah[WegdhW/*S`UWS`V dWg^SdbSfda^S`VfS] WS`k bdVhWf[hW_ V&egdWe'f a eSXWgSdV`SfgdS^dVeagdUWe']` SfgdS^dVeagdUWe'S`VXadVef be axXdVe'[``SfgdS^dVeagdUWe'S`VXadVef a eSXWgSdV`SfgdS^dVeagdUWe'S`V UA`fda^S k fkbWe'aXXdVe'[``SfgdS^dVeagdUWe'S`VXadVefe) Ua`fda^aYf[`YabWdSf[a`TSeWa`bVd_[fe [eegW'Tk fZW SfgdS^J VeagdUWe': V_[`[efdSf[a`e[` bdah[`UVe'S`VfS] WVWS^SUf[a`SYS[`ef S`k [^[Uff Wb^affsf[a`)[` ebVUf S`V UA`fda^S`k USdYae fdS`e[ff`Y[` XadVef S`V dS`YWdaSVe S`VfS] WVWS^SUf[a`SYS[`ef S`k [^[Uff Wb^affsf[a`)[` ebVUf S`X UA`fa^S k USdYae fdS`e[ff`Y[` XadVef S`V dS`YWdaSVe S`VfS] WVWS^SUf[a` fa aV_[[' ebVUf[a` fa as X_eUSf[` YfZWe_gYYWW YaaVe)S`V USddk agf dWg'Sd[` ebVUf[a` fa i aaV_[` fe S`VXSUfad[Ve)

IŽ

?J O G ZSe Sbbdaj [_ SfWk USdt[Wagf ea_ W1/3--- ZWtfSdWe aX W b'S fSf[a`e [`fZV <Seb[S` dWt[a` SXWtfZWh[Ufadk aXfZWJ Wta'gf[a` f[^/ -- 5+LZWF SfgdS^J WeagdUWe S` VO SfWeZWW E S` SYW_ Wf N[e[a` ZSe Wh[eSYW fZWdWZST['[fSf[a` aX 1----- ZWtfSdWe aX W XadWefe Se i W^Se b'S` fSf[a` aX/----- ZWtfSdWe aX` W XadWefe Tk /-/2

 $\label{eq:linear} LZ[e bda YdS_efSdfWr[fZWLZ[dV?[hW*P VSd=VhWab_Wf HYS + LZWAadVefe[fZWeW dWx[a`ei VhWVVVdSVWV VgWfa VyUVee[hWaYY[Y)ea[^[XVhf]/[fk S VahVh*YdSl[Y+ LZW_S[SUf[h[f[W*g` VVhfZ[e bda YdS_ SdWSe Xa^ai e7]$

J $VUS_S[a] S V dWWWWSf[a] SUf[h[f] We % Ug V[Y XWU[Y) eWWV[YS V eWWV[Y& dWgUf[a] a XVW/dSVSf[a] XSUface % Ug V[Y Xa dWef XdWe S V [^WWS^ Lgff[Ye&S V Xa d_ g^Sf[a] a X_ g^f[bgdbaeWXa dWef dk b^S e+$

13 %Té . 4 %Sé

*>efST'[eZ_ Wf aXS`Sf[a`S^XadWef dWeagdUWSeeWee_ Wf ekefW_Xad Ua^WUf[a`SWa[S^ 56 %T& .4 %T& S`VeSfWP[fW[_SYWe'S`VbdWeSdSf[a` aXV[XXWaWf fkbWe aX_Sbe geWVXad_S`SYW_Wf aXXadWefe+

 $\label{eq:setstargenergy} $$ efst'[eZ_WfaXS`Sf[a`S^Wh[da`_WfS^_a`[fad`YekefW_SetSbSdfaXS`Sf[a`S^[`Xad_Sf[a`ekefW_XadUa^Wdf[a`S`VV[eeW_[`Sf[a`aX[`Xad_Sf[a`S_a`YdWWdS`feWfade+$

*? adWef >j b^a[fSf[a` E a` [fad[` YHda YdS_

 $LZ[e bda YdS_ _a` [fade fZWWyb^a[fSf[a` S` Vi aa V Ugff[` Yab WdSf[a` [` fZW< Seb[S` XadWefe dWf[a`) S` V S[_ e fa ZWb VWdWSeWi aa V ZSdh Wef Xda_ fZW< Seb[S` XadWefe a` fZWISe[e a XWh[da`_ WfS^Sbbda SUZWe+LZW< Seb[S` XadWef [e fZWa` 'k XadWef fZSf [e '[UW eWW Xadi aa V ZSdh Wef [` BIS` +Aai VMWb] fZWXYYgdWe ZSV S'i Ske eZai` S VW0[` [` Y fdW V[` fZWbSef Xagd?[hWP V&d= VMWab_ Wf H'S` e+; SeWa` fZWefSf[ef[Ue) fZW_ V&S S` gS^i aa V ZSdh Wef [` fZW?[def?[hWP V&d= VMWab_ Wf H'S` %656*. 661&i Se STagf . 4 _ [^a` UgT[U_ WWde Ua_ bSdWi [fZ fZWXYYgdW-61_ [^a` UgT[U_ WWde dWadVWW [` /--5+$

45 % & . 5

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*? adWef J WeagdUWe: eeWe_ Wf aXBBS 7dWadf[YS V[Xid_ Sf[a` ekef \underline{W} e fa See[ef [fZWUa^WUf[a`) hWu[XUSf[a`) ek` fZWe[e] [fWabdWiSf[a` S` V V[eeW_ [Sf[a` aX[`Xid_ Sf[a` ... 2 We ... 1/ %UE ... 2 We ... 2 We ... 1/ %UE ... 2 WE .

*? ad_g^Sf[a`aXS eWaXVWY[[f]a`eaX] Wk fWd_e geWV[`XadWef dWeagdUWSeeWee_Wf 56 % .// % S S V Ud[fWd[S S`V[`V[USfade aXK?E)[`U'gV[`YXad^ai XadWef UahWd) b/S`fWVXadWefe S`V USfWYad[We aXbdafVUfWW SdWSe+

25 %**S**& 56

' ?[`S`U[`YegefS[`ST'W	* @ahWa _ Wf dWagdUWe S^aUSfWV XadegefS[`ST^WXadWefe	fl) °fl* fl. °ł " °ł # °
XadWef_S`SYW_Wf	_ S` SYW_ Wf [`XadWef eWfad S` VafZWdeWfade egUZ Se	ł\$*ł%ł&
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	* <d₩[f svwshs[^st^wik="" ts`][`yekefw_="" x\$u['[f[w&_="" xad<br="">K?E +</d₩[f>	
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' <sbsufk mtg[^v[`y<="" td=""><td>$*>j bS e[a a XXad_S^S V[Xad_S^fdS[] Ye Xad XadWefdk$</td><td>fl&°fl4°fl7°ł'°ł*ł+</td></sbsufk>	$*>j bS e[a a XXad_S^S V[Xad_S^fdS[] Ye Xad XadWefdk$	fl&°fl4°fl7°ł'°ł*ł+
S`VfWVZ' a^aYk fdS`eXM	efSXX-	ł, °ł-°ł.
	*>j bS`e[a` aXXad_ S^UagdeWe'aXXWWWTk g`[hWeb[f[We'a` XadWefdk+	
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' KfS] WZa^VWd	*	1

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BS ZSe Ua`fda^WW fZWaee a XXadWef Uah Wa fZdag YZ Se Wd[We a X_ WSegdWe i [fZ]`fZW0^{dV} S V1^{rZ} Wh Wab_Wf b da YdS_e [Ug V]`YdWi[e[`YS V[_bdah[`YW][e[]`Y'Si e S V[ef[fgf[a`S^efdgUfgdWa X XadWef S V dS`YWS`VadYS`[lSf[a`)dWg U[Y'a YY]`Yfa S ZS'Xji [fZVdSi S^a XeUSffWiWV /h Wefa U] Xka_ XadWefe) dWi[e[`YXadWef_S S YYW_Wf b'S`e) dWa'SU[`YXee[^WXg We Xad Xg Wi aa V[`h[^^SYWe'S`V dW_ afW SdWse) Wh Wab[`Yb'S fSf[a` XadWefe) SXXadWefSf[a`) dWa dWefSf[a`S`V dWefa dSf[a` a XVWdSVWW XadWefe) Xad_g^Sf[`Y`W_XadWefdk b da YdS_e i [fZ W_bZSe[e a` ^S`VeUSb Wb da fWff[a`S`V Ua`eWhSf[a` a Xg`[cgW Wfa keefW_e) dWa dYS [l[`YXadWef YgSdV) dS[e[`YfZWSi SdW We a XfZWYW WS^bgT'[US`V USbSU[fk* Tg[^V[`Y[`Ua_g`f[We'Se i W^Se a XXw[`YXad_S^S V[`Xad_S^fdS[`[Ye) WjbS`V[`Y[egdS`UWLah Wd $\label{eq:started_st$

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