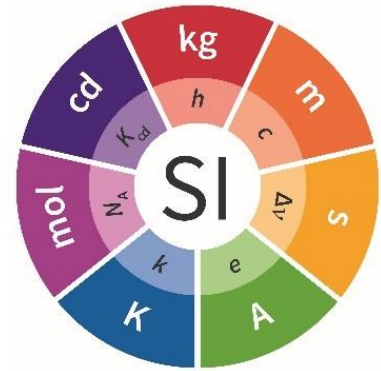


SI

He whakarāpopototanga o te Pūnaha Waeine ā-Ao, te SI



Ko te Mātauranga Inenga te mātauranga o te inenga me tōna whakamahinga. Kei roto i te mātauranga inenga ko ngā āhuatanga ariā, ā-ringa hoki o te inenga, ahakoa te warawara inenga me te momo mahi a te tangata.

I whakatūria te Mana ā-Ao mō ngā Taumaha me ngā Inenga (BIPM), e te Ūpoko 1 o te Tiriti ā-Ao o te Mita i te 20 o Mei 1875. He mea whakahau tēnei Mana ki te whakarato i te pūtake mō te pūnaha inenga mārāma kotahi kia whakamahia e te ao katoa, ā, ka whakahaeretia i raro te mana o te Komiti ā-Ao mō Ngā Taumaha me Ngā Inenga (CIPM). I takea mai te pūnaha tekau, i te wā o te Pāhoru Wīwī, he mea ahū mai i te mita me te manokaramu i te tau 1799. I raro i te Tiriti ā-Ao o te Mita, i hanga houtia ngā tauria taketake ā-ao o te mita me te manokaramu. I whakamanatia ōkawatia ērā i te hui tuatahi a te Rūnanga Whānui mō Ngā Taumaha me Ngā Inenga (CGPM) i te tau 1889. I te tau 1960 i whakatauria, i whakatūria ōkawatia hoki i te hui 11 o te CGPM te Pūnaha Waeine ā-Ao (SI). Mai i taua wā i whakahoutia te SI i roto i te wā kia whai whakaaro ki ngā kauneketanga o te pūtaiao me te hiahia ki ngā inenga i ngā wāhi hou. I whakamanahia te whakahounga matua whakamutunga e te CGPM 26 (2018), i whakatau ka takea mai te SI i ngā uara ā-tau pūmau o **ngā aumou tautuhinga** e whitu, ā, ka ahū mai i konei ngā whakamāramatanga o ngā waeine pūtake e whitu o te SI. He whakarāpopototanga o te **Mātārere SI** tēnei tuinga, he tānga i whakaputaina e te BIPM he kōrero taipitopito whakamārāma i te tūnga o te SI i tēnei wā.

Ko te SI te pūnaha o ngā waeine ko:

- te auau whakawhiti tino rauangi ngao-iti maho o te ngota konukororā 133 (caesium 133 atom), $\Delta\nu_{\text{Cs}}$, ko 9 192 631 770 Hz,
- te tere o te tūrama i te korekore, c , ko 299 792 458 m/s,
- te aumou Planck, h , ko $6.626\ 070\ 15 \times 10^{-34}$ J s,
- ko te hiko taketake, e , ko $1.602\ 176\ 634 \times 10^{-19}$ C,
- te aumou Boltzmann, k , ko $1.380\ 649 \times 10^{-23}$ J/K,
- te aumou Avogadro, N_A , ko $6.022\ 140\ 76 \times 10^{23}$ mol⁻¹,
- te whaikaha whakaputa tūrama o te iraruke taetahi o te auau 540×10^{12} Hz, K_{cd} , ko 683 lm/W,

ā, e pā tahi ana te hertz, te joule, te coulomb, te lumen, me te watt me ngā tohu waeine hāngai ko Hz, J, C, lm, me te W, ki ngā waeine te hēkona, te mita, te manokaramu, te ampere, te kelvin, te tiwhanga, me te kārara, me ngā tohu waeine hāngai, s, m, kg, A, K, mol, me cd, e ai ki te $\text{Hz} = \text{s}^{-1}$, $\text{J} = \text{kg m}^2 \text{s}^{-2}$, $\text{C} = \text{A s}$, $\text{lm} = \text{cd m}^2 \text{m}^{-2} = \text{cd sr}$, me te $\text{W} = \text{kg m}^2 \text{s}^{-3}$.

E tautuhi ana ēnei whakamāramatanga i te uara ā-tau pū o ia aumou ina kīia te uara i roto i te waeine SI hāngai. Mā te whakapūmau i te uara ā-tau pū, ka tautuhia te wae, i te mea me ōrite te hua o te **uara ā-tau** me te **waeine** ki te **uara** o te aumou, ā, he pūmau.

Kua kōwhiria ngā aumou tautuhinga, ina tangohia ngātahitia, e kapi ana ngā waeine katoa i ngā waeine o te SI. Me kī, kāore he ritenga tētahi ki tētahi i waenga i ngā aumou tautuhinga me ngā waeine pūtake o te SI, hāunga mō te auau konukororā $\Delta\nu_{\text{Cs}}$ me te aumou Avogadro N_A . Ko ngā waeine SI he hua nō ngā pū o ēnei aumou e whitu me tētahi tauwehe ahunga-kore.

Hei tauria: mā te $\text{Hz} = \text{s}^{-1}$, ka taea te kimi te kotahi mita mai i te tere o te tūrama c me te auau konukororā $\Delta\nu_{\text{Cs}}$,

$$1 \text{ m} = \left(\frac{c}{299\ 792\ 458} \right) \text{ s} = \frac{9\ 192\ 631\ 770}{299\ 792\ 458} \frac{c}{\Delta\nu_{\text{Cs}}} \approx 30.663\ 319 \frac{c}{\Delta\nu_{\text{Cs}}}.$$

Ko te huatau o ngā waeine pūtake me ngā waeine pūhua i whakamahia hei tautuhi i te SI tae noa ki te tau 2018. Ka whakaūngia ēnei kāwai, ahakoa kua kore e waiwai i roto i te SI, nā te haratau me te hōrapa o te whakamahi. Kei roto i te Tūtohi 1 i raro ngā whakamārāma o ngā waeine pūtake, ka whai atu i te whakamāramatanga o te SI e ai ki ngā aumou tautuhinga e whitu.

Tūtohi 1 Ngā waeine pūtaketake e whitu o te SI

Rahinga	Waeine SI
wā	Ko te hēkona , te tohu s , te waeine SI o te wā. I tautuhia mā te tango i te uara ā-tau pūmau o te auau konukororā, $\Delta\nu_{Cs}$, te auau whakawhiti tino rauangi ngao-iti maho o te ngota konukororā 133, kia $9\ 192\ 631\ 770$ inā kīia i roto i te waeine Hz, ā, he ōrite ki s^{-1} .
roa	Ko te mita , te tohu m , te waeine SI o te roa. I tautuhia mā te tango i te uara ā-tau pūmau o te tere o te tūrama i te korekore, c , kia $299\ 792\ 458$ ina kīia i roto i te waeine $m\ s^{-1}$, ina ka tautuhia te hēkona e ai ki $\Delta\nu_{Cs}$.
papatipu	Ko te manokaramu , te tohu kg , te waeine SI o te papatipu. Ka tautuhia mā te tango i te uara ā-tau pūmau o te aumou Planck, h , kia $6.626\ 070\ 15 \times 10^{-34}$ ina kīia i roto i te waeine J s, ā, he ōrite ki te $kg\ m^2\ s^{-1}$, ina ko te mita me te hēkona ka tautuhia e ai ki c me $\Delta\nu_{Cs}$.
iahiko	Ko te ampere te tohu A , te waeine SI o te iahiko. Ka tautuhia mā te tango i te uara ā-tau pūmau o te whana taketake, e , kia $1.602\ 176\ 634 \times 10^{-19}$ ina kīia i roto i te waeine C, ā, he ōrite ki A s, ina ko te hēkona ka tautuhia e ai ki $\Delta\nu_{Cs}$.
pāmahana taunekeneke rewarau	Ko te kelvin , te tohu K , te waeine SI o te pāmahana taunekeneke rewarau. Ka tautuhia mā te tango i te uara ā-tau pūmau o te aumou Boltzmann, k , kia $1.380\ 649 \times 10^{-23}$ ina kīia i roto i te waeine $J\ K^{-1}$, ā, he ōrite ki $kg\ m^2\ s^{-2}\ K^{-1}$, ina ko te manokaramu, te mita me te hēkona ka tautuhia e ai ki h , c me $\Delta\nu_{Cs}$.
rahinga matū	Ko te tiwhanga , te tohu mol , te waeine SI o te rahinga matū. Kei roto i te tiwhanga kotahi ko $6.022\ 140\ 76 \times 10^{23}$ ngā korakora taketake. Ko tēnei tau ko te uara ā-tau pūmau o te aumou Avogadro, N_A , ina kīia i roto i te waeine mol^{-1} , ā, ka kīia ko te tau Avogadro. Ko te rahinga o te matū, tohu n , o tētahi pūnaha he waeine o te maha o ngā wāhi taketake kua āta whakahuatia. Ko ngā wāhi taketake he ngota, he rāpoi ngota, he katote, he irahiko, he momo matūriki kē rānei, he rōpū whāiti rānei nō ēnei korakora.
kukū whakaputa tūrama	Ko te kānara , tohu cd , te waeine SI o te kukū whakaputa tūrama i tētahi ahunga. Ka tautuhia mā te tango i te uara ā-tau pūmau o te whaikaha whakaputa tūrama o te auau iraruke taetahi 540×10^{12} Hz, K_{cd} , kia 683 ina kīia i roto i te waeine $lm\ W^{-1}$, ā, he ōrite ki te $cd\ sr\ W^{-1}$, $cd\ sr\ kg^{-1}\ m^{-2}\ s^3$ rānei, ina ka tautuhia te manokaramu, mita me te hēkona e ai ki h , c me $\Delta\nu_{Cs}$.

Ka whakaahuatia ērā atu rahinga katoa he "rahinga pūhua", nā ka inea ki te waeine pūhua, e tautuhia hei otinga o ngā pū o ngā waeine pūtaketake. Ka whakaingoatia ngā waeine pūhua rua tekau mā rua ki tētahi ingoa motuhake, e rārangi ana ki te Tūtohi 2.

Tūtohi 2 Ngā waeine pūhua me ngā ingoa motuhake i roto i te SI

Rahinga pūhua	Ingoa o te waeine pūhua	Tohu mō te waeine	Kiānga e ai ki ētahi atu waeine
horahanga	tātoro (radian)	rad	m/m
koki āhua ahu-toru	tātoro pūrua (steradian)	sr	m^2/m^2
auau	hertz	Hz	s^{-1}
tōpana	newton	N	$kg\ m\ s^{-2}$
pēhanga	pascal	Pa	$N/m^2 = kg\ m^{-1}\ s^{-2}$
pūngao, tōpanatanga, whakaputanga wera	joule	J	$N\ m = kg\ m^2\ s^{-2}$
Hiko/kaha, whakaputanga iahiko rukeruke	watt	W	$J/s = kg\ m^2\ s^{-3}$
whana hiko	coulomb	C	A s
rerekētanga iahiko moe	volt	V	$W/A = kg\ m^2\ s^{-3}\ A^{-1}$
āheipuringa	farad	F	$C/V = kg^{-1}\ m^{-2}\ s^4\ A^2$
parenga iahiko	ohm	Ω	$V/A = kg\ m^2\ s^{-3}\ A^{-2}$
kaha kawē iahiko	siemens	S	$A/V = kg^{-1}\ m^{-2}\ s^3\ A^2$
whakaputanga autō	weber	Wb	$V\ s = kg\ m^2\ s^{-2}\ A^{-1}$
kiato whakaputanga autō	tesla	T	$Wb/m^2 = kg\ s^{-2}\ A^{-1}$
whakaputanga iahiko o roto	henry	H	$Wb/A = kg\ m^2\ s^{-2}\ A^{-2}$
pāmahana Toharau	waeine Celsius	$^{\circ}C$	K
whakaputanga tūrama	lumen	lm	cd sr
rukunga tūrama	lux	lx	$lm/m^2 = cd\ sr\ m^{-2}$
hohenga ka kīia ko te ngota ira karihi	becquerel	Bq	s^{-1}
pota mimiti, kerma	gray	Gy	$J/kg = m^2\ s^{-2}$
pota ōrite	sievert	Sv	$J/kg = m^2\ s^{-2}$
hohenga whakakōkī	katal	kat	$mol\ s^{-1}$

Ahakoā ōrite tahi te hertz me te becquerel ki te hēkona tauutuutu, ka whakamahia te hertz ki ngā tītohunga tāruarua, ko te becquerel ia ki ngā tukanga tūponotanga tupurangi o te horo iraruke.

Ko te waeine o te pāmahana Celsius ko te waeine Celsius, °C, ko tōna rarahi ko te rite o tō te kelvin, K, te waeine o te pāmahana taunekeneke rewarau. Ka pāhono te rahinga pāmahana Celsius t ki te pāmahana taunekeneke rewarau T mā te whārite $t/°C = T/K - 273.15$.

Ko te sievert ka whakamahia hoki mō ngā rahinga o te ‘pota ōrite ahunga’, o te ‘pota ōrite whaiaro’ hoki.

He maha noa atu ngā rahinga i ngā waeine. Mō tēnā rahinga, mō tēnā rahinga, kotahi tonu te waeine o te SI (ahakoā whakahuatia ai ki ngā tikanga rerekē maha mā te whakamahi i ngā ingoa motuhake), ā, ka taea te waeine kotahi o te SI te whakamahi hei whakahua i ngā uara o ngā rahinga rerekē maha (hei tauira, ka taea te waeine J/K o te SI te whakamahi hei whakahua i te uara o te whakaputanga wera me te kaumingomingo). Nā reira, he mea nui kia kua te waeine e whakamahia i tōna kotahi hei tāutu i tētahi rahinga. Ka tika hoki tēnei mō ngā tuhinga pūtaiao, mō ngā taputapu ine anō hoki (arā, kia tohu te pānuitanga o tētahi taputapu ine i te rahinga e hāngai ana, me te waeine).

Kei reira ngā rahinga me te waeine kotahi, 1, arā, ngā ōwehenga o ngā rahinga e rua nō te momo kotahi. Hei tauira, ko te taupū ata tāhapa ko te ōwehenga o ngā horo e rua; ko te inenga whakaaetanga pūngaoko te ōwehenga o te whakaaetanga o tētahi kawenga iahiko mātarua ki tō te ātea noa. Arā ētahi rahinga me te āhua o te tatauranga, hei tauira, te nui o ngā urunga ā-pūtau, matai koiara ā-rāpoi ngota rānei. Kotahi anake te waeine o ēnei rahinga. Ko te āhua o te waeine kotahi he huānga nō ngā pūnaha waeine katoa. Nō reira ko te whakaaro ko ngā rahinga me te waeine kotahi ka ahu atu ki te SI. Heoi anō, ina whakahuatia ngā uara o ngā ahunga-kore, kāore e tuhia te waeine 1.

Ngā taurea ā-ira me ngā taurea-iho ā-ira o ngā waeine SI

Kua whakaaetia he huinga kūmua hei whakamahi tahi me ngā waeine SI, e āhei ai te whakahua i ngā uara o ngā rahinga e tino nui ake ana, e tino iti ake ana rānei i te waeine SI kūmua kore. Ka taea ēnei te whakamahi tahi me te katoa o ngā waeine SI. E whakarārangitia ana ngā kūmua SI ki te Tūtohi 3.

Tūtohi 3 Ngā kūmua SI

Tauwehe	Ingoa	Tohu	Tauwehe	Ingoa	Tohu
10 ¹	deca	da	10 ⁻¹	deci	d
10 ²	hecto	h	10 ⁻²	centi	c
10 ³	mano	k	10 ⁻³	milli	m
10 ⁶	mega	M	10 ⁻⁶	micro	μ
10 ⁹	giga	G	10 ⁻⁹	nano	n
10 ¹²	tera	T	10 ⁻¹²	pico	p
10 ¹⁵	peta	P	10 ⁻¹⁵	femto	f
10 ¹⁸	exa	E	10 ⁻¹⁸	atto	a
10 ²¹	zetta	Z	10 ⁻²¹	zepto	z
10 ²⁴	yotta	Y	10 ⁻²⁴	yocto	y
10 ²⁷	ronna	R	10 ⁻²⁷	ronto	r
10 ³⁰	quetta	Q	10 ⁻³⁰	quecto	q

He whānui te whakamahinga o ngā kūmuri -rau, -mano i te reo Māori ki ngā waeine hei tauwehe o te 10⁻² (rau) me te 10⁻³ (mano), arā, hei tauira ko te mitarau, me te karamumano. He rangiwhāwhā, he ōrite hoki tēnei whakamahinga ki ngā momo hanga reo Māori.

Ina whakamahia ngā kūmua, ka whakakotahitia te ingoa kūmua me te ingoa waeine kia kupu kotahi. Waihoki, ka tuhia me te āputa kore te tohu kūmua me te tohu waeine kia kotahi te tohu, he mea ka taea tonu te whakarea ake mā tētahi pū, ahakoā he aha. Hei tauira, ka taea e tātou te tuhi: manomita, km, microvolt, μV; femtohēkona, fs rānei.

Ina whakamahia kūmua kore ngā waeine SI, e pēnei ana te whakaahua i te huinga waeine ka puta hei mea **pipiri**: ka whakamahia anake ko ngā waeine pipiri, he rite tonu te āhua o ngā whārite i waenga i ngā uara ā-tau o ngā rahinga ki ngā whārite i waenga i ngā rahinga tonu. He painga hangarau tō te whakamahi i te huinga waeine pipiri, hei tauira, mō te tuanaki taurangi (tirohia te Mātārere SI).

Ko te manokaramu kg tētahi mea whakararu, nō te mea kei roto kē i tōna ingoa tētahi kūmua, he mea heke mai nō nehe rā anō. Ko ngā taurea me ngā taurea-iho o te manokaramu ka tuhia mā te whakakotahi i ngā kūmua ki te karamu: nāwai tuhi ai tātau i te millikaramu, mg, ehara i te micromanokaramu, μkg.

Ngā waeine i waho o te pūnaha SI

Ko te SI anake te pūnaha waeine kei te whakaaetia ā-aotia, nō reira he tino huanga ki te whakaū i te kōrerorero tahi ā-ao. Mā te whakamahinga i te pūnaha SI ka ngāwari ake te whakaakoranga pūtaiao. Nā ēnei take, kei te whakahauhia kia whakamahia ngā waeine SI ki ngā pekanga katoa o te pūtaiao, o te hangarau. Ko ētahi atu momo waeine, arā, ngā mea ehara i te SI, ka tautuhia noatia ki te āhua o ngā waeine SI me ngā tau huringa.

Hāunga tērā, kei te whakamahia whānuitia tonu ētahi waeine ehara i te waeine SI. Ko ētahi, pēnei i te meneti, te haora me te rā hei waeine o te wā, ka whakamahia ake tonu atu nō te mea kua hōhonu rawa te tīti ki tō tātau ahurea. Ko ētahi anō, kei te whakamahia mō ngā take hītori, hei whakatutuki i ngā wawata o ētahi rōpū whakaaro motuhake, nō te mea rānei kāore he mea pai kē a te SI. Ka noho tonu hei mana motuhake mā te tohunga pūtaiao te whiriwhiri i ngā waeine e tino rite ana mō tōna kaupapa. Heoi anō, ina whakamahia ngā waeine ehara i te SI, kia whakahuatia anō tāna huringa ki te tikanga SI. Kua whakarārangitia ki te Tūtohi 4 ētahi waeine ehara i te SI me ngā tau huringa ki te tikanga SI. Mō tētahi rārangi whānui ake, tirohia te Mātārere SI.

Tūtohi 4 *Ētahi waeine ehara i te SI*

Rahinga	Waeine	Tohu	Huringa ki SI
wā	meneti	min	1 min = 60 s
wā	haora	h	1 h = 3600 s
wā	rā	d	1 d = 86 400 s
rōrahi	rita	L, l rānei	1 L = 1 dm ³
papatipu	tana	t	1 t = 1000 kg
pūngao	electronvolt (eV) J	eV	1 eV = 1.602 176 634 × 10 ⁻¹⁹ J

Tīmata ai ngā tohu waeine ki te pūmatua ina whakaingoatia mō te tangata (hei tauira, ampere, A; kelvin, K; hertz, Hz; coulomb, C rānei). Ki te kore ka tīmata ki te pūriki (hei tauira, mita, m; hēkona, s; tīwhanga, mol rānei), hāunga te rita. Ko te tohu rita anake te mea awere: ka taea he pūriki, he pūmatua L rānei, ka tukua hoki te pūmatua 'L' kei pōraruru te tangata i waenganui i te pūriki l me te tau kotahi, l.

Te reo pūtaiao: te whakamahi i te SI hei whakahua i ngā uara rahinga

Ka tuhia te uara o tētahi rahinga hei otinga o tētahi tau me tētahi waeine. Ko te tau e whakarea ki taua waeine te uara ā-tau o te rahinga o taua waeine. Ka mahue he wāhi wātea kotahi i waenganui i te tau me te waeine i ngā wā katoa. Kei runga tonu i te waeine kua kōwhiria te uara ā-tau, nā reira ahakoa he rite te uara rahinga tērā e rerekē pea ngā uara ā-tau ki te whakahuatia ki ngā waeine rerekē, pēnei i ēnei tauira i raro nei.

Ko te tere āwhiwhi o tētahi pahikara ko

$$v = 5.0 \text{ m/s} = 18 \text{ km/h.}$$

Ko te roangaru o tētahi o ngā rārangi konutai kōwhaiwhai ko

$$\lambda = 5.896 \times 10^{-7} \text{ m} = 589.6 \text{ nm.}$$

Ka tāngia tītahatia ngā tohu rahinga, otirā, ko te tikanga he pū kotahi anō ēnei o te arapū Rātini, arapū Kariki rānei. Ka taea ngā pūmatua, pūriki rānei te whakamahi, ā, ka taea hoki ētahi atu kōrero mō te rahinga te tāpiri hei kupu hauraro, hei kupu whakataiapa rānei.

Arā noa ētahi tohu e whakahaua ana mō ētahi rahinga nunui, he mea homai nā ngā mana pēnei i te Whakahaere Whakamana Waeine ā-Ao (ISO) me ngā ūniana rōpū pūtaiao ā-ao maha noa, pērā i te International Union of Pure and Applied Physics (IUPAP) me te International Union of Pure and Applied Chemistry (IUPAC). Ko ētahi tauira ko te:

T mō pāmahana taunekeneke rewarau

C_p mō te kahapupuri wera i tētahi pēhanga aumou

x_i mō te hautanga tiwhanga (nuinga hautanga) o te momo i i

μ_r mō te kaha hiko ā-korekore.

Ka tuhia rōmanatia (tūtika) ngā tohu waeine, ahakoa te momotuhi kei te whakamahia ki ērā atu tuhinga tawhio noa. He āhuatanga pāngarau ēnei, ehara i te whakapotonga noa iho; e kore e tuhia me te irakati i muri (hāunga ia i te mutunga o te rerenga kōrero), kore kau anō te pū s mō ngā mea takitini. He mea āta whakahau anō kia tika tonu te whakamahi i ngā tohu waeine, ā, e whakaahuatia ana ki ētahi tauira i te Mātārere SI. Tērā e nui ake pea i te pū kotahi te tohu waeine. Ka tuhia ki te pūriki, engari he pūmatua te pū tuatahi ina kua tapaina te waeine mō tētahi tangata. Heoi anō, ki te tuhia katoatia te ingoa waeine, kia tīmatahia ki te pūriki (hāunga rā kei te tīmātanga ia o te rerenga kōrero), kia wehewehea te waeine i te tangata (hei tauira, ko te pāmahana o te 293 kelvins).

Ina tuhia te uara o tētahi rahinga hei whakaotinga o tētahi uara ā-tau me tētahi waeine, ka taea tonu kia whakamahia te tau me te waeine i runga i ngā tikanga noa o te taurangi. Hei tauira, ka taea tonu te whārite $T = 293 \text{ K}$ te tuhi kia $T/\text{K} = 293$. Whakaahuatia ai tēnei hātepe ko te whakamahinga o te rahinga tuanaki, te taurangi o ngā rahinga rānei. He pai tonu te ōwehenga o tētahi rahinga ki tōna waeine hei whakaupoko mō te tīwae o tētahi tūtohi, hei tapa i ngā tuaka kauwhata rānei, e noho ai hei tau noa ngā tuhinga ki te tūtohi, ngā tohu ki ngā tuaka rānei. Kei te tauira (Tūtohi 5) ko tētahi tūtohi o te tere pūrua ki te pēhanga, ā, kua pēnei anō te tapanga o ngā tīwae.

Ripanga 5 Taurira o te ūpoko tīwae o tētahi tūtohi o te tere pūrua ki te pēhanga

p/kPa	$v^2/(\text{m/s})^2$
48.73	94766
72.87	94771
135.42	94784

Ka haere tonu ngā whakaritenga tikanga noa o te taurangi ina hangaia he otinga whakarea, otinga wehe rānei o ngā waeine. Ina hangaia he otinga o ngā waeine, kia waiho he wāhi wātea i waenganui i ngā waeine (tērā anō rānei e taea te whakamahi he ira haurua tiketike ki waenga hei tohu whakareanga). Kia mahara ki te nui o te wāhi wātea: e tohu ana te otinga o te mita me te hēkona mā te m s (me te wāhi wātea), engari he manohēkona kē te ms (kāore he wāhi wātea). Waihoki, ina hangaia ngā otinga waeine whīwhiwhi, whakamahia he taiapa, he pū tōraro rānei hei karo i ngā rangiruatanga. Hei taurira, ka homai te tau pūmau hau titiwha R mā te:

$$\begin{aligned} pV_m/T = R &= 8.314 \text{ Pa m}^3 \text{ mol}^{-1} \text{ K}^{-1} \\ &= 8.314 \text{ Pa m}^3/(\text{mol K}). \end{aligned}$$

Ina whakatakoto i ngā tau ka taea te tohu ā-ira te tuhi hei ira (arā, hei kopi), hei piko rānei, e ai ki ngā āhuatanga. Mō ngā tuhinga i te reo Ingarihi ko te ira te tikanga, heoi mō ētahi reo maha o ētahi atu whenua ko te piko te tikanga.

Ki te nui ngā mati o tētahi tau, ko te tikanga kia whakarōpūtia ngā mati kia takitorutia ki tēnā taha, ki tēnā taha o te ira, kia ngāwari ai te kōrero. Ehara i te mea kia pēnei rawa, engari auau noa te pēneitanga, otirā he whaitake tonu tēnei. Ki te pēnei te whakatakoto, kia wehea ngā whakarōpū mati takitoru mā tētahi wāhi wātea; kia kaua anō te ira, te piko rānei e whakamahi. Ka taea te warawara o te uara ā-tau o tētahi rahinga te whakaatu pai noa mā te hoatu i te warawara o ngā mati tāpua iti rawa ki ngā taiapa i muri i te tau.

Hei taurira: Ko te uara irahiko papatipu kua homai ki te rārangi 2014 CODATA o ngā tau pūmau taketake ko

$$m_e = 9.109\,383\,56(11) \times 10^{-31} \text{ kg},$$

ko te 11 te warawara whānui i ngā mati whakaoti kua homai mō te uara ā-tau.



Mō ētahi atu mōhiohio, haere ki te paetukutuku BIPM, tirohia rānei te **Mātārere SI** tānga 9, e wātea ana i

www.bipm.org

Nā te Komiti Tohutohu mō ngā Waeine (Comité Consultatif des Unités - CCU) o te Komiti ā-Ao mō ngā Taumaha me ngā Inenga (Comité International des Poids et Mesures – CIPM) tēnei whakarāpopototanga i whakariterite, ā, nā te BIPM i tā.