

Energi- och miljöfysik

Energi

Arbete

$$W = \int_{x_1}^{x_2} \vec{F} \cdot d\vec{x}$$

Translationsenergi

$$W_k = \frac{1}{2} \cdot m \cdot v^2 = \frac{p^2}{2 \cdot m}$$

Rotationsenergi

$$W_r = \frac{1}{2} \cdot I \cdot \omega^2 = \frac{L^2}{2 \cdot I}$$

Potentiell energi

$$W_p = m \cdot g \cdot h$$

Elastisk energi

$$W_e = \frac{1}{2} \cdot k \cdot x^2$$

Effekt

$$P = \frac{dW}{dt}$$

Tryck

$$p = \frac{dF}{dA}$$

Barometerformeln

$$p = p_0 + \rho \cdot g \cdot h$$

Lufttrycket

$$p = p_0 \cdot e^{-[M \cdot g / (R \cdot T)] \cdot y}$$

Värme

Temperaturförändring

$$dQ = m \cdot c \cdot dT$$

$$Q = m \cdot c \cdot \Delta T$$

Fasövergång

$$Q = m \cdot L$$

Gaser

Allmänna gaslagen

$$p \cdot V = n \cdot R \cdot T$$

$$R = 8,314 \text{ 51 J/(mol} \cdot \text{K)}$$

$$p \cdot V = N \cdot k \cdot T$$

$$k = 1,380 \text{ 658} \cdot 10^{-23} \text{ J/K}$$

Molmassa

$$M = \frac{m}{n}$$

Massdensitet

$$\rho = \frac{m}{V}$$

Partikeldensitet

$$n_0 = \frac{N}{V}$$

Termodynamik

Arbete

$$W = \int_{V_1}^{V_2} p \cdot dV$$

Inre energiändring

$$\Delta U = n \cdot C_V \cdot \Delta T$$

1:a Huvudsatsen

$$Q = \Delta U + W$$

Värmekapacitet

$$C = M \cdot c$$

$$C_V = \frac{f}{2} \cdot R$$

$$C_P = C_V + R$$

$$\gamma = \frac{c_P}{c_V} = \frac{C_P}{C_V}$$

Adiabatisk process (Poissons ekvation)

$$p \cdot V^\gamma = \text{konstant}$$

$$T \cdot V^{\gamma-1} = \text{konstant}$$

$$T \cdot p^{-(\gamma-1)/\gamma} = \text{konstant}$$

Kretsprocesser

$$e = \frac{W}{Q_H} \text{ (verkningsgrad)}$$

$$e = \frac{Q_H}{W} \text{ (värmefaktor)}$$

$$e = \frac{Q_C}{W} \text{ (köldfaktor)}$$

Carnot/Stirlingprocesserna

$$e = \frac{T_H - T_C}{T_H} \text{ (verkningsgrad)}$$

$$e = \frac{T_H}{T_H - T_C} \text{ (värmefaktor)}$$

$$e = \frac{T_C}{T_H - T_C} \text{ (köldfaktor)}$$

Värmetransport

Värmeeffekt

$$H = \frac{dQ}{dt}$$

Fouriers lag (värmeledning)

$$H = -k \cdot A \cdot \frac{dT}{dx}$$

Linjär värmeledning

$$H = -k \cdot A \cdot \frac{\Delta T}{\Delta x}$$

Radiell värmeledning

$$H = -k \cdot 2 \cdot \pi \cdot L \cdot \frac{(T_2 - T_1)}{\ln \frac{r_2}{r_1}}$$

Newtons avkylningslag (värmeövergång)

$$H = -h \cdot A \cdot (T_S - T_\infty)$$

Stefan Boltzmanns lag (värmestrålning)

$$H = \varepsilon \cdot \sigma \cdot A \cdot T^4$$

$$\sigma = 5,6705 \cdot 10^{-8} \text{ W/(m}^2 \cdot \text{K}^4)$$

Ljus

Fotonens energi

$$E = h \cdot f$$

$$h = 6,626\,076 \cdot 10^{-34} \text{ J} \cdot \text{s}$$

Vågtal

$$\sigma = \frac{1}{\lambda}$$

Ljusets

utbredningshastighet

$$c = f \cdot \lambda$$

$$c = 299\,792\,458 \text{ m/s}$$

Intensitet

$$I = \frac{P}{A}$$

Stefan Boltzmanns lag

(värmestrålning)

$$P = H = \varepsilon \cdot \sigma \cdot A \cdot T^4$$

$$\sigma = 5,6705 \cdot 10^{-8} \text{ W/(m}^2 \cdot \text{K}^4)$$

Wiens förskjutningslag

$$\lambda_{\text{max}} = \frac{a}{T}$$

$$a = 2,897\,756 \cdot 10^{-3} \text{ K} \cdot \text{m}$$

Atomer

Rydbergs formel

$$\frac{1}{\lambda} = R \cdot Z^2 \cdot \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$R = 1,097 \cdot 10^7 \text{ m}^{-1}$$

Totala energin

$$E_n = - \frac{m \cdot e^4}{2 \cdot (4 \cdot \pi \cdot \varepsilon_0 \cdot \hbar)^2} \cdot \frac{Z^2}{n^2}$$
$$= -13,6 \cdot \frac{Z^2}{n^2} \text{ eV}$$

Röntgenstrålning

Bromsstrålning

$$\lambda_{\text{min}} = \frac{h \cdot c}{e \cdot U_{\text{acc}}}$$

Moselys lag

$$\frac{1}{\lambda_{K\alpha}} = \frac{3}{4} \cdot R \cdot (Z-1)^2$$

Molekyler

Reducerad massa

$$\mu = \frac{m_1 \cdot m_2}{m_1 + m_2}$$

Rotationsenergi

$$E_r = \frac{\hbar^2}{2 \cdot I} \cdot \ell \cdot (\ell + 1) \equiv B \cdot \ell(\ell + 1)$$

$$\ell = 0, 1, 2, \dots$$

$$\hbar = h / (2 \cdot \pi)$$

$$I = \mu \cdot r^2 \text{ (två-atomig)}$$

Vibrationsenergi

$$E_v = \hbar \cdot \omega_0 \cdot \left(v + \frac{1}{2} \right)$$

$$v = 0, 1, 2, \dots$$

Egenfrekvens

$$\omega_0 = \sqrt{\frac{k}{\mu}}$$

Strålning

Kärnan

$$A = Z + N$$

Kärnans storlek

$$R \approx (1,2 \cdot 10^{-15} \text{ m}) \cdot A^{1/3}$$

Energi och massa

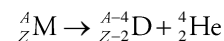
$$E = m \cdot c^2$$

Bindningsenergi

$$B = (Z \cdot m(^1\text{H}) + N \cdot m_n - m(^A\text{X})) \cdot c^2$$

$$1 \text{ u} = 931,502 \text{ MeV}/c^2$$

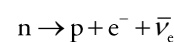
Alfasönderfall (α -sönderfall)



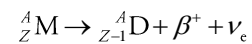
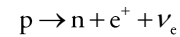
$$Q = (m({}^A_Z\text{M}) - m({}^{A-4}_{Z-2}\text{D}) - m(\alpha)) \cdot c^2$$

$$E_k(\alpha) = \frac{Q}{1 + \frac{m(\alpha)}{m({}^{A-4}_{Z-2}\text{D})}}$$

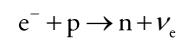
Betasönderfall (β -sönderfall)



$$Q_{\beta^-} = (m({}^A_Z\text{M}) - m({}^A_{Z+1}\text{D})) \cdot c^2$$

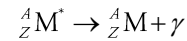


$$Q_{\beta^+} = (m({}^A_Z\text{M}) - m({}^A_{Z-1}\text{D}) - 2m_e) \cdot c^2$$



$$Q_e = (m({}^A_Z\text{M}) - m({}^A_{Z-1}\text{D})) \cdot c^2$$

Gammäsönderfall (γ -sönderfall)



Sönderfall

$$N(t) = N_0 \cdot e^{-\lambda t}$$

Halveringstid

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

Aktivitet

$$A = \left| \frac{dN}{dt} \right| = \lambda \cdot N(t) = A_0 \cdot e^{-\lambda t}$$

Växelverkan

Alfapartiklarnas växelverkan

$$Q = E_k \cdot \frac{4 \cdot m_e}{M}$$

Bromsförmåga

$$S = \frac{dE_k}{dx}$$

Fotonens växelverkan

$$I(x) = I_0 \cdot e^{-\mu x}$$

Halveringstjocklek

$$HVL = \frac{\ln 2}{\mu}$$

Biologiska effekter

Absorberad dos

$$D = \frac{dE}{dm}, [1 \text{ Gy}]$$

Ekvivalent dos

$$H_{T,R} = w_R \cdot D_{T,R}, [1 \text{ Sv}]$$

Effektiv dos

$$E = \sum_T w_T \cdot H_T, [1 \text{ Sv}]$$

Sammanfattning av 1:a huvudsatsen ($\Delta Q = \Delta U + W$)

Process	Definition	ΔQ	ΔU	W
Isobar	$\Delta p = 0$	$n \cdot C_p \cdot \Delta T$	$n \cdot C_V \cdot \Delta T$	$p \cdot \Delta V$
Isokor	$\Delta V = 0$	$n \cdot C_V \cdot \Delta T$	$n \cdot C_V \cdot \Delta T$	0
Isoterm	$\Delta T = 0$	W	0	$n \cdot R \cdot T \cdot \ln(V_2/V_1)$
Adiabat	$\Delta Q = 0$	0	$n \cdot C_V \cdot \Delta T$	$- n \cdot C_V \cdot \Delta T$

Prefix	Beteckning	Storlek
yetta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
hekto	h	10^2
deka	da	10^1
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
mikro	μ	10^{-6}
nano	n	10^{-9}
piko	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

Ytor och volymer

	Area	Volym
Cirkel	$\pi \cdot r^2$	
Klot	$4 \cdot \pi \cdot r^2$	$4 \cdot \pi \cdot r^3 / 3$

Energienheter inom fysiken

J	kWh	eV	kcal
1	$0,277778 \times 10^{-6}$	$6,2418 \times 10^{18}$	$0,238846 \times 10^{-3}$
$3,6 \times 10^6$	1	$22,471 \times 10^{24}$	859,845
$1,6021 \times 10^{-19}$	$44,503 \times 10^{-27}$	1	$38,266 \times 10^{-24}$
$4,1868 \times 10^3$	$1,163 \times 10^{-3}$	$2,6132 \times 10^{22}$	1

Tryckenheter

Pa	bar	torr	atm
1	10×10^{-6}	$7,50062 \times 10^{-3}$	$9,86923 \times 10^{-6}$
100×10^3	1	750,062	0,986923
133,322	$1,33322 \times 10^{-3}$	1	$1,31579 \times 10^{-3}$
$101,325 \times 10^3$	1,01325	760	1

Exempel: Trycket 1 atm = $101,325 \cdot 10^3$ Pa = 1,01325 bar = 760 torr.

Periodiska systemet

Grupp**

Period	1											18							
	IA											VIIIA							
	1A											8A							
1	1 H 1.008	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	2 He 4.003	
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	
3	11 Na 22.99	12 Mg 24.31	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 ----- -----	9 VIII --	10 ----- -----	8 ----- -----	11 IB 1B	12 IIB 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80	
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3	
6	55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 190.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)	
7	87 Fr (223)	88 Ra (226)	89 Ac~ (227)	104 Rf (257)	105 Db (260)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 --- (0)	111 --- (0)	112 --- (0)	114 --- (0)	116 --- (0)	118 --- (0)				

Lanthanide Series*	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinide Series~	90 Th 232.0	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)