

Index

- adiabatic
 - definition, 27
 - demagnetization, 168
 - sudden process as, 36
 - throttling, 79
- adiabatic process, 43
- antiferromagnetism, 155
- bias in probabilities, 267
 - define, 266
 - entropy, 267
 - measure of, 264
- Boltzmann, xii
 - constant, 29
 - microcanonical theory, 89
- Bose–Einstein
 - condensate, 246, 250
 - condensate wave function, 252
 - condensation, 249
 - grand potential, 248
 - integrals, 296
 - internal energy, 249
 - occupation number, 248
 - thermodynamics, 248
- bosons, 107, 250, 252, 253
- Carnot, xi
 - cycle, 69
 - engine, 66
- chemical potential, 5, 6, 26, 28, 192
- chemical reactions, 196
- Clausius, 2, 85
- Clausius, historical note, xi, xii
- coherent, 10, 252
- cosmic microwave background (CMB), 255
- Debye model, 131
 - Debye temperature, 133
 - density of states, 273
 - internal energy, 133
 - heat capacity, 133
- decoherence, 18, 86, 91
- degeneracy, 94, 96
- elastomer, 99
- hydrogenic, 100
- internal quantum, 96
- macroscopic, 96
- one-dimensional harmonic oscillator, 101
- demagnetization
 - factor, 284
 - field, 284
 - tensor, 284
- density of states
 - definition, 271
 - one dimension, particles in, 271
- density operator, 7
 - definition, 12
 - density matrix, 12
 - density matrix, examples, 21
 - equation of motion, 14
 - information and the, 13
 - mixed state, 15
 - properties, 12
 - pure state, 12, 14
 - thermal, defined, 19
- diamagnetism, 155
- diathermic, 40
- differential, 49
 - exact, 28, 50
 - Euler’s criterion, 51
 - Green’s theorem, 51
- diffusive equilibrium, 193
- Dirac delta function
 - definition, 233
 - property, 272
- Dirac notation, 9
- Einstein model
 - one-dimensional, 124
 - partition function, 126
 - thermal Lagrangian, 126
 - three-dimensional, 128
 - Einstein temperature, 130
 - heat capacity, 130
 - internal energy, 129
 - partition function, 128

- Einstein, historical note, 2
- elasticity
 elongation, 7, 26
 entropy, 141
 equation of state, 141
 extension, 37
 lab experiment, 151, 275
 non-ideal equation of state, 150
 one-dimensional model, 136
 partition function, 140
 tension, 5, 26, 29
 thermodynamics of, 143
 three-dimensional non-ideal, 147
- elastomer, 29, 98
 degeneracy, 99
- electric
 constitutive relation, 279
 field, 5, 30
 fields in matter, 278
 polarization, 26, 30
 susceptibility tensor, 30
- electromagnetic
 Maxwell's equations, 285
 polarizations, 288
 vector potential, 288
 wave equation, classical, 289
 waves, 285
- electromagnetic field
 hamiltonian, quantized, 290, 291
 operator, quantized, 291
- energy
 microscopic system, 10
- ensembles, xii
- enthalpy, 54
 definition, 39, 75
 Maxwell's relation, 75
- entropy, xii, xiii, 20, 21, 58, 60, 85, 92
 definition, 53
 examples, 60
 of mixing, 114
- equation of state, 28
 dielectric, 30
- equilibrium
 thermodynamic, definition, 3
- Euler's homogeneous function theorem,
 54, 268
 proof, 268
- exoplanet surface temperature, 223
- Fermi energy, 232
- Fermi gas model, 233
- Fermi–Dirac
 average particle number, 231
 chemical potential, 234, 236
 electron gas model, 238
 free electron approximation, 229
 function, 231
 grand partition function, 230
 grand potential, 231
 heat capacity, 236
 integrals, 293
 internal energy, 232, 236
 occupation number, 231
 pressure, equation of state, 232
 thermodynamics, 231
- fermions, 106
- ferrimagnetism, 155
- ferromagnetism, 155
 critical exponent, 173
 Curie–Weiss susceptibility, 174
 Gibbs potential, 171
 Heisenberg exchange, 169
 Heisenberg model, 169
 order parameter, 172
- field
 energy, 282
 external, 279
 external magnetic, 282
 local average, 282
 magnetic, effective, 283
 mean, 283
- fields
 demagnetizing, 278
- First Law of Thermodynamics, 4
 heat, 25, 27
 incremental, 28
 work, 25, 26
- force, 25
- free expansion, 56
- functional, 88, 266
- gamma function, 251
- gas law, 29
 ideal, 29
 derivation, 107
 pressure, 29
 temperature, 29
 van der Waals, 59, 115
 derivation, 184
- Gibbs, xii
 canonical theory, 93
 correction, 109
 entropy paradox, 113
 partition function, 93

- Gibbs potential, 78
 magnetic, 283
 Gibbs–Duhem equation, 201
 grand canonical
 entropy, 179
 Euler’s theorem, 181
 ideal gas example, 182
 internal energy, 178
 particle number, 178
 partition function, 177
 potential function, 179
 pressure, 179
 thermodynamics, 178
 heat, 4, 66
 heat capacity, 38
 constant pressure, 39
 constant volume, 38
 Dulong–Petit, 123
 entropy, 81
 Helmholtz potential
 canonical, 95
 definition, 76
 Maxwell’s relation, 76
 ideal gas, 106
 barometric equation, 194
 charged, 194
 entropy, Sackur–Tetrode equation, 112
 heat capacity, 112
 Helmholtz potential, 112
 in Earth’s gravitational field, 193
 in rotating cylinder, 195
 internal energy, 111
 pressure, equation of state, 113
 thermal Lagrangian, 108
 information, 11, 18
 missing, 22
 purity, 14
 Shannon, 86
 internal energy, 4, 9, 19, 27, 36
 blackbody, moving frame, 260
 free expansion, 57
 Maxwell’s relation, 73
 isenthalpic, 53
 isochoric, 39
 isothermal, 31, 37
 law of mass action, 198
 line integration, 59
 macroscopic, xii
 averages, 4
 definition, 3
 magnetic
 constitutive relation, 279
 field
 internal, 283
 fields, in matter, 278
 thermodynamic potentials, 278
 magnetism, 154
 constitutive relation, 158
 de Haas–van Alphen effect, 155
 enthalpy, 158
 fundamental equation, 157, 160
 Gibbs potential, 158
 Helmholtz potential, 158
 internal fields, 283
 magnetic field, 5, 30
 magnetic moment, 6
 magnetic susceptibility, 30
 magnetic work, 156, 158
 magnetization, 26, 282
 fluctuations, 167
 magnetization vector, 160
 work in applied fields, 160
 Mattis, xi, xiii
 Maxwell, xii
 thermodynamic relations, 50, 74, 76–78
 mean field approximation, 283
 ferromagnetism, 170
 gravitational interaction, 187
 van der Waals equation, 185
 microstates, xii
 minimum bias, 88, 266
 mixed state, 15
 negative temperature, 120
 normalization, state function, 10
 open systems, 6, 192
 operator
 density, thermodynamic, 86
 elongation, 5
 fluctuations, 19
 function of, 21
 hamiltonian, 8
 hamiltonian, thermal, 87
 hermitian, 9, 11
 magnetization, 5
 particle number, 6
 polarization, 5
 pressure, 5
 quantum hamiltonian, 5
 trace, definition, 13
 vector potential, 5

- paramagnetism, 154, 161
 Curie regime, 165
 entropy, 165
 fluctuations, 167
 Gibbs potential, 165
 heat capacity, 166
 magnetization, 164
 partition function, 163
 thermal Lagrangian, 163
 thermodynamics, 164
- partial differentiation, 50, 55
- partition function, 93
 blackbody moving frame, 259
 ideal gas, 109
- Pauli exclusion principle, 106, 228
- Pauli susceptibility, 237
- periodic boundary conditions, 239
- phonons, 125
- Planck radiation function, CMB, 262
- Planck, historical note, 2
- polymer
 rubber, 29
 rubber band, 36
- Poynting vector, 222
 blackbody, moving frame, 261
- pressure, 19, 26, 179
- purity, 20, 21, 263
- quantum
 “bra”, 9
 “ket”, 8, 9
 average value, 10
 eigenfunctions, 9, 11
 eigenvalues, 9, 11
 expectation value, 8–11
 fluctuations, 8
 hamiltonian, 5, 8
 microscopic, 7
 probabilities, 8
 probability, 9
 probability amplitude, 10
 pure state, 11, 12
 state function, 8
 superposition theorem, 10
 wavefunction, 7, 11
- quantum concentration, n_Q , 111
- radiation thermodynamics, moving frame, 259
- Schottky model, 117
 heat capacity, 119
 two-level system, 117
- Schrödinger, equation, 7
- Schwartz inequality, 263
- Second Law of Thermodynamics, 54, 65, 69, 85
- specific heat, 38
- stars
 formation of, 186
 giant molecular clouds, 187
 gravitational collapse, 189
 gravitational equation of state, 189
- state function, 8
 normalization, 13
- Stern–Gerlach, 16
- strain, 26, 42
 definition, 29
- stress, 26, 42
 definition, 29
- surface adsorption, 204
 dissociative, 207
 Langmuir isotherm, 207
 Langmuir model, 204
- temperature, 5, 27
- tension
 surface, 26
- thermal expansivity, 42
- thermal Lagrangian
 Bose–Einstein, 247
 canonical theory, 93
 CMB, 257
 definition, 267
 elastic, 138, 140
 Fermi–Dirac, 229
 microcanonical theory, 90
 open system, 177
 radiation, 214
 Schottky two-level model, 118
- thermal radiation
 entropy, 221
 hamiltonian, classical, 212
 Helmholtz potential, 216
 momentum density, 224
 partition function, 215
 Planck constant, 212
 Planck quantization, 212
 stardust blow-out, 225
 Stefan–Boltzmann law, 217, 221
 thermodynamics of, 214
 Wien’s law, 220
- thermodynamic identity, 53
- thermodynamics
 equilibrium states, 30
 fluctuations, definition, 3
 surroundings, 4

-
- surroundings, definition, 3
 - system, definition, 3
 - throttling, 79
 - van der Waals, equation, 186
 - van der Waals, historical note, 2
 - variables
 - conjugate pairs, 26
 - extensive, 26
 - intensive, 26
 - state, 28
 - thermal, 3
 - white dwarf stars, 241
 - mass–radius constant, 243
 - work, 4, 25
 - electric, 159
 - irreversible, 33, 34, 62
 - magnetic, 159
 - quasi-static, 30, 34, 37
 - reversible, 31
 - Young's modulus, 42, 136
 - zeta function, 251