

## INDEX

- Absolute entropy *see* Entropy, absolute  
 Absolute humidity 130  
 Absolute temperature *see* Absolute thermodynamic temperature  
 Absolute thermodynamic temperature 181  
   Definition of 190  
   Measurement of 191  
   Scale of 191  
 Absolute zero temperature 325  
 Absorption 301  
   Dynamic 301  
   Rate 301  
 Acceleration 32  
 Acentric factor *see* Pitzer acentric factor  
 Activity coefficient 9, 257, 303, 309  
   Consistency 287, 346  
   Measurements 287  
 Adiabatic flame temperature 368  
 Adiabatic mixing temperature 252  
 Adiabatic reactor temperature 368  
 Adiabatic system 74  
 Adiabatically impossible process 181–182  
 Adiabatically irreversible process 182  
 Aerosol 60  
 Aggregation 60  
 Air-conditioner 194  
 Air-conditioner efficiency *see* Refrigerator efficiency  
 Air pollution 372, 422  
 Amorphous phase 52  
 Antoine equation 117  
 Area, definition 30  
 Area orientation 30  
 Atom balances 362, 404  
 Atomic matrix 401  
 Atomic matrix, rank 401  
 Avogadro number 27  
 Azeotrope 275  
   Heterogeneous 294  
   Negative 291  
   Positive 291  
   Temperature-minimum 291  
   Reference 244, 258, 299  
   Significance 235  
 Chemical reaction 358  
   Definition 358  
   Differential extent 364  
   Differential reaction coordinate 364  
   Direction of 358, 373  
   Dynamic extent *see* Dynamic yield  
   Dynamic yield 414  
   Endothermic 358  
   Enthalpy change of 358, 364  
   Equilibria *see* Reaction equilibria  
   Equilibrium, condition for 374  
   Equilibrium constant 375  
   Temperature dependence of 377  
   Equilibrium extent 380  
   Equilibrium yield 364  
   Exothermic 358  
   Extent 363  
   Gibbs free energy of 375  
   Heterogeneous 359  
   Homogeneous 359  
   Irreversible 361  
   Kinetics 361  
   Mechanism 360  
   Practically irreversible 361, 383  
   Reaction coordinate for 364  
   Reversible 361  
   Stoichiometry 362  
   Stoichiometric coefficient 362  
   Stoichiometric table 382, 384  
   Yield *see* Extent  
 Clapeyron equation 117, 228  
 Clausius–Clapeyron equation 118, 229  
 Climate change 302, 417  
 Closed system 74  
 Cloud 48  
 Coalescence 60  
 Coffee-pot problem, 150  
   Energy balance for closed system 151  
   Energy balance for open system 157  
   Mass balance equation for open system 157  
 Azeotropy 57, 290  
   Condition for modified Raoult's law 290  
   Condition for regular solution model 291  
 Batch reactor 365  
 Bilayer 60  
 Binary phase diagram *see* Phase diagram, binary  
 Binodal 262  
   For regular solution model 264  
   Line 265  
   Region 269  
 Birefringence 52  
 Boiling point 56  
 Boiling point elevation 352  
   Method 353  
 Boltzmann distribution 107, 333  
 Boltzmann's constant 336  
 BTU, energy unit 39  
 Bubble-point pressure 279, 302  
 Bubble-point temperature 57, 281, 302  
 Buoyancy force 30  
 Calorie, or cal 39  
 Canonical ensemble *see* Ensemble, canonical  
 Canonical partition function 333, 336  
 Carbon footprint 420  
 Carnot cycle  
   Description 186  
   Efficiency 187–188  
   Significance 187  
   Theorem 187  
 Carnot engine *see* Carnot cycle  
 Catalyst 399  
 Chemical bond 358  
 Chemical potential 9, 232  
   And fugacity 245  
   Definition 232  
   Dependence on mole fraction 234  
   Dependence on pressure 234  
   Dependence on temperature 234  
   Geometrical interpretation 261

- Colligative property 320, 351, 353–354  
Colloid *see* Colloidal dispersion  
Colloidal dispersion 60  
  Lyophilic 60  
  Lyophobic 60  
Colloidal particle 59  
Compressibility factor 106, 115, 123  
  Definition 106  
  Generalized correlation for 125–126  
  Lee–Kessler correlation 126  
  Partial molar 256  
  Pitzer correlation 126  
Compressibility, isothermal *see* Isothermal compressibility  
Compressible liquid 17  
Conditions at equilibrium 235  
Conduction heat transfer 73  
Conservation of energy *see* Energy balance equation  
Conservation of mass *see* Mass balance equation  
Consistency  
  Thermodynamic, of VLE data 287  
  *see also* Gibbs–Duhem equation  
Consolute point 270  
Consolute temperature 270  
Constitutive equation 5, 7, 66, 103  
Continuous flow reactor 364  
Continuum description 3  
Control volume 83  
Convection 83  
Convective heat transfer 83  
Conversion factors 425  
Conversion of heat into work 184  
Corresponding states principle 125  
Critical molar volume 113  
Critical point 113  
Critical pressure 113  
Critical solution temperature  
  Lower 266  
  Upper 266  
Critical temperature 51  
Cryoscopy 354  
Crystalline phase 52  
Cubic equation of state *see* Equation of state, cubic  
Cubic liquid crystal *see* Liquid crystal, cubic  
Cycle 81  
Data sources 425  
Decomposition temperature 392  
Definite integral *see* Integral, definite  
Deformation 33  
  Elastic 33  
  Plastic 33  
Degree of freedom 236  
Density 103  
Derivative 31  
  Mixed second partial 111  
  Partial 76  
  Second 77  
  Total 32  
Deviations from ideality *see also* Solution model  
  Negative 260  
  Positive 260  
Dew-point pressure 279, 302  
Dew-point temperature 57, 282, 302  
Differential 16, 75  
  Differential criterion for exact 78, 82  
  Exact 78  
  Inexact 78  
  Integral criterion for exact 82  
  Integral of exact 81  
  Integral of inexact 81  
  Function for exact differential 81  
Direction of chemical reaction 358, 373  
Direction of heat transfer 223  
Direction of mass transfer 235  
Distillation 57, 274  
  Batch 275  
  Column 274  
Dynamic extent of reaction *see* Chemical reaction, dynamic extent  
Ebullioscopy 353  
Efficiency  
  Actual of engine 192  
  Ideal of engine 192  
  Of air-conditioner *see* Of refrigerator  
  Of Carnot heat engine 192  
  Of gasoline engine 372  
  Of heat engine 184–185  
  Of heat pump 196  
  Of refrigerator 195–196  
Eigenstate *see* Quantum state  
Electrodynamic forces 29  
Electromagnetic forces 29  
Empirical temperature 62  
Emulsion 59  
  Bicontinuous 59  
  Definition 59  
  Multiple 59  
  Oil-in-water 59  
  Water-in-oil 59  
Endothermic reaction 358  
Energy 37  
  Chemical 193, 417  
  Electrical 418  
  External 38  
  Internal 71  
  Kinetic 38  
  Mechanical 37  
  Potential 37  
  Solar 74, 417  
  Total 72  
  Total mechanical 37–38  
  Units 39  
Energy balance equation, 73  
  Differential, for closed system 76  
  For Earth 420  
  General integral equation in terms of enthalpies 91  
  General integral equation in terms of internal energies 89  
  Macroscopic, for closed systems 72–101  
  Macroscopic, for open systems 85  
  Macroscopic, for open systems at steady state 88  
  Macroscopic, for open systems at unsteady state 85  
  Time derivative form, closed systems 75  
Energy conservation *see* Energy balance  
Energy cost of materials 422  
Energy density 40, 419  
Energy efficiency 418–419  
Energy sources 417  
Engine  
  Carnot *see* Carnot engine  
  Cycles 193  
  Efficiency *see* Efficiency, engine  
  Heat *see* Heat engine  
Ensemble 330  
  Average 330  
  Canonical 331  
  Microcanonical 331  
Enthalpy 91, 214  
  Data on standard enthalpies of formation 426  
  Definition 91–92  
  Effect of pressure 219  
  Effect of temperature 219  
  Measurement 92  
  Of ideal gas 218  
  Of formation, standard 366, 426  
  Of liquid 98, 218  
  Of mixing 259  
Enthalpy change of reaction 358, 364  
  Temperature dependence of 366  
Enthalpy of mixing 92, 259  
Entropy 181  
  Absolute 328  
  And disorder 9, 337  
  Calculation 201, 205  
  For ideal gas 201–202  
  For liquid 202  
  For purely thermal process 203  
  Definition of 200  
  Dependence on pressure 215

- Dependence on temperature 215
- Dependence on volume 216
- Derivation 198
- Inequality principle 206, 209
- Measurement of 8, 181, 219
- Molecular interpretation of 337
- Of mixing 252, 259
- Relative 201
- Residual 328
- Significance 8, 199
- Equal a-priori probabilities, principle of 331
- Equation of state 65, 103
  - And Minus First Law 61
  - Cubic 112, 114, 122–123
  - Data 425
  - Generalized correlation for 125–126
  - Generic cubic 123
  - Lee–Kessler correlation 126
  - Pitzer correlation 126
  - Of ideal gas 19, 105
  - Of liquids 126
  - Of mixtures 135
  - Of nonideal gases 111
  - Of solids 126
  - Of solutions 105
  - Of wet steam 127
  - Peng–Robinson 123
  - Pitzer correlation 126
  - Redlich–Kwong 122
  - Van der Waals 112
  - Virial 123
  - Virial, pressure-explicit 124
  - Virial, volume-explicit *see* Virial
- Equilibrium
  - Mechanical 15
  - Phase 226
- Equilibrium extent of reaction *see* Chemical reaction, equilibrium extent
- Equilibrium yield of a reaction *see* Chemical reaction, equilibrium yield
- Ergodic hypothesis 330
- Exact differential *see* differential
- Excess enthalpy 259
- Excess entropy 259
- Excess Gibbs free energy 259
- Excess quantity 259
- Excess surface density 348
- Excess volume 259
- Existence of equilibrium phase; *see* Minus Second Law
- Excluded volume 110
- Exothermic reaction 358
- Extensive property 61, 342
- External fields effects 11
- Extraction; *see* liquid–liquid extraction
- Feasibility of a process 181
- First and Second Laws combined 205
  - For one-component closed system
    - First version 205
    - Fourth version 214
    - Second version 214
    - Third version 214
  - For two-component open system 233
- First Law 5, 71
  - First version 71
  - Generalized 72–73
- First Law of thermodynamics *see* First Law
- Flame temperature, adiabatic *see* Adiabatic flame temperature
- Flow work 90
- Fluid, definition of 34
- Fluid phase 50
- Foam 59
- Food calorie *see* kilocalorie
- Force
  - Body 29
  - Definition 28
  - Electrodynamic ch 2
  - External 15, 29
  - Fundamental 29
  - Gravity 24, 28
  - Hydrodynamic 30
  - Hydrostatic 30
  - Intermolecular 29
  - Internal 29
  - Macroscopic 29
  - Magnetostatic ch 2
  - Microscopic 29
  - Pressure 29
  - Shear 29
  - Strong 29
  - Surface 29
  - Surface tension 29 *see also* Surface tension
  - Weak 29
- Force balance 15, 30
  - Macroscopic 15
  - Microscopic 16
- Free volume 110
- Freezing point depression 354
- Fugacity 9, 244
  - And chemical potential 245
  - Calculation 246
  - Definition 245
  - Dependence on pressure 248
  - Dependence on temperature 248
  - Measurement 246
  - Of component in mixture 255
  - Of liquid 247
  - Of nonideal gas 246
  - Units 244
- Fugacity coefficient 9, 245–246
  - Of component in mixture 255
- Fundamental forces 29
- Gas constant *see* Universal gas constant
- Gas expansion
  - Ideal gas 141
    - Adiabatic irreversible 144
    - Adiabatic reversible 142
    - Isothermal irreversible 141
    - Isothermal reversible 142
  - Nonideal gas 147
- Gas-in-liquid dispersion 59
- Gas–liquid equilibrium 300
- Gas phase *see* Phase, gas
- Generalized correlation *see* Equation of state
  - General 125
  - Lee–Kessler 126
  - Pitzer 126
- Geothermal heat pump *see* Heat pump
- Geothermal heat pump efficiency *see* Heat pump efficiency
- Gibbs adsorption isotherm equation 348
- Gibbs–Duhem equation 9, 342
  - Derivation 343
  - For activity coefficients 287, 345
    - Differential criterion for 345
    - Integral criterion for 346
  - For partial molar volumes 345
  - For two phases 348
- Gibbs free energy 9, 214
  - Data on standard Gibbs free energy of formation 426
  - Definition of 214
  - Dependence on pressure 220
  - Dependence on temperature 220
  - Dependence on volume 220
  - Minimum 225
  - Of formation 329
  - Of mixing
    - Excess 258
    - Of ideal gas 254
    - Nonideal 258
  - Of chemical reaction 375
  - Standard of formation 426
- Gibbs–Helmholtz equation 378
- Gibbs phase rule 236
  - Mnemonic for 236
- Gibbs theorem 254
- Global warming 303, 420
  - And energy balance equations 74
- Gravity force 24, 28
- Gravitational constant 24
- Greenhouse gas 419
- Green's theorem on a plane 81

- Heat 73  
 Conduction 73  
 Definition 73  
 Measurement 73  
 Molecular basis of 337  
 Of reaction *see* Chemical reaction, enthalpy change of  
 Radiation 73
- Heat capacity 71  
 At constant pressure 94  
 At constant volume 93  
 Data 426  
 Definition 71, 93  
 Molar 93  
 Of ice 326  
 Of ideal gases 96–97  
 Of liquids 95, 98  
 Of nonideal gases 98  
 Of solids 98, 327  
 Of solutions 99  
 Ratio 143  
 Specific 71, 93  
 Translational kinetic energy contribution to 107
- Heat engine 184
- Heat engine efficiency 184, 192
- Heat exchanger 158  
 Heat exchanger, cocurrent 159  
 Heat exchanger, 158  
 Heat exchanger, countercurrent 159
- Heat flux 89
- Heat of mixing *see* Enthalpy of mixing
- Heat pump 196, 418
- Heat pump efficiency 196
- Heat of reaction *see* Enthalpy change of reaction
- Heat radiation *see* Heat, radiation
- Heat reservoir 194
- Heat, specific *see* Heat capacity
- Heat transfer 182 *see also* Heat
- Heat transfer by convection *see* Convective heat transfer
- Heat transfer coefficient 86, 166  
 Definition 86  
 Overall 162  
 Overall external 162  
 Overall internal 162
- Helmholtz free energy 214  
 Definition 214  
 Dependence on pressure 219  
 Dependence on temperature 220  
 Minimum 224
- Henry's constant 300  
 Data for 426
- Henry's law 300
- Henry's law constant *see* Henry's constant
- Heterogeneous reaction *see* Chemical reaction, heterogeneous
- Hexagonal liquid crystal 55
- Humidity, absolute 130
- Humidity, relative 130
- Ideal gas 19  
 Ideal gas expansion 141  
 Adiabatic irreversible 144  
 Adiabatic reversible 142  
 Entropy change of 201–202  
 Isothermal irreversible 141  
 Isothermal reversible 142
- Ideal gas mixture 129, 253
- Ideal gas temperature *see* Temperature, ideal gas
- Ideal solution *see* Solution, ideal
- Immiscible liquids 309
- Incompressible fluid 19
- Incompressible liquid 16
- Indefinite integral 16
- Independent component 237
- Inexact differential *see* Differential, inexact
- Infinite dilution 300
- Integral 16  
 Definite 17  
 Double 81  
 Indefinite 16  
 Line 81  
 Surface 89  
 Volume 89
- Integrating denominator 80
- Integrating factor 80
- Intensive property 61, 342
- Interface 58  
 Fluid 59
- Interfacial region 58
- Interfacial region, thickness 58
- Interfacial tension 59
- Intermolecular forces 29
- Internal combustion engine 371 and ch 18
- Internal energy, 71  
 Definition 71  
 Dependence on pressure 217  
 Dependence on temperature 109  
 Dependence on volume 217  
 Measurement 71, 219  
 Molecular interpretation 72  
 And First Law 71
- Irreversible work 36
- Isenthalpic process 168
- Isentropic process 206
- Isobaric process 146
- Isolated system 331
- Isopiestic vapor pressure method 351
- Isothermal process 141
- Isothermal compressibility 17, 103  
 Of ideal gas 104  
 Of liquid water 104
- Joule, energy unit 36
- Joule's experiments 70
- Joule's hypothesis 70
- Joule–Thomson coefficient 169
- Joule–Thomson effect 169
- Kelvin equation 347
- Kilocalorie, or kcal 39
- Kilowatt hour, or kWh 40
- Kinetic energy 38
- Lagrange undetermined multipliers 333, 406
- Lamellar liquid crystal 54
- Laplace–Young equation 347
- Le Chatelier principle 377, 386
- Lee–Kessler correlation 126
- Length 27  
 Length scale 3, 50  
 Length units 27
- Lewis and Randall rule 256
- Lipid bilayer *see* bilayer
- Liposome 54, 60
- Liquid aerosol 59
- Liquid crystal 53
- Liquid crystalline phase 53  
 Cholesteric 54  
 Cubic 55  
 Hexagonal 55  
 Lamellar 54  
 Lyotropic 53  
 Nematic 54  
 Smectic 54  
 Thermotropic 53
- Liquid-in-gas dispersion 59
- Liquid–liquid equilibrium 235, 293, 307
- Liquid–liquid extraction 308
- Liquid–vapor equilibrium 308
- Log mean temperature difference 163
- Lower critical solution temperature 265
- Margules equation 260
- Mass balance, carbon dioxide 419
- Mass balance equation  
 For carbon dioxide 419  
 For methane 419  
 For open system 84
- Mass transfer 301, 311, 316  
 Coefficient 301  
 Driving force for 301, 311, 316  
 Rate 301  
 Resistance 301

- Mass units 28
- Maximum possible useful work  
224–225
- Maxwell's equal area construction 121,  
229, 231
- Maxwell's relations 221
- McCabe–Thiele method 281
- Mechanical energy 37
- Mechanical energy conservation principle  
39
- Mechanical work 35
- Mechanics 1
- Mechanics, definition 27
- Mechanics, laws 1, 4
- Mechanics, primitive concepts 27
- Melting point 229  
Effect of pressure 229
- Mercury vapor exposure 119
- Metastable equilibrium phase 52
- Metric system of units 27
- Metrics of learning thermodynamics  
*see* Thermodynamics, metrics of  
learning
- Micelle 55, 60
- Microcanonical ensemble *see* Ensemble,  
microcanonical
- Microemulsion 60
- Microstate 337
- Minus First Law 4, 61–62, 67  
And equation of state 4, 61  
Statement 4, 61
- Minus First Law of thermodynamics  
*see* Minus First Law
- Minus Second Law 4, 61–62, 67  
And existence of equilibrium phase 4,  
61  
Statement 4, 61
- Minus Second Law of thermodynamics  
*see* Minus Second Law
- Mixed second partial derivative 77
- Mixing process 147  
Athermal 92  
Endothermic 92, 249  
Enthalpy change of 92, 259  
Entropy change 252, 259  
Exothermic 92, 249  
Gibbs free energy change 253  
Volume change 131
- Molar volume of a mixture 131
- Nanoparticle 59
- Natural variable 214
- Nematic liquid crystal *see* Liquid crystal,  
nematic
- Nernst partition coefficient 310
- Newton's second law of motion 30
- Non-equilibrium systems 6
- Nonideal enthalpy of mixing *see* Excess  
enthalpy
- Nonideal entropy of mixing 259
- Nonideal gas equation of state 111  
*see also* Equation of state
- Nonideal gas mixture 255–256
- Nonideal Gibbs free energy of mixing *see*  
Excess Gibbs free energy of mixing
- Nonideal solution model 260  
Asymmetric 260  
Symmetric 260
- Nonideal volume of mixing *see* Volume of  
mixing
- Nucleation  
Heterogeneous 263  
Homogeneous 263
- Nuclei 263
- Number-average polymer molecular  
weight 320
- Number of independent reactions 237, 400
- Open system 74, 84  
Mass and energy balance equations for  
88–89, 91, 84
- Order  
Long-range 52  
Orientational 52–53  
Positional 52–53  
Short-range 52
- Ordinary differential equation 153  
Inhomogeneous 153  
Homogeneous 154
- Osmometry 320
- Osmosis 317  
Application to electrolytes 319  
Application to polymer molecular  
weight 319  
Definition 317  
Reverse 322  
Van 't Hoff analysis 317
- Osmotic equilibrium 317
- Osmotic pressure 317
- Partial derivative 76  
First 76  
Mixed second 77  
Second 77
- Partial molar compressibility factor 256
- Partial molar enthalpy 249
- Partial molar entropy 234
- Partial molar Gibbs free energy *see*  
chemical potential
- Partial molar volume of a component in a  
mixture 131  
Geometrical representation 134
- Partition function, canonical 333
- Peng–Robinson equation of state 123
- Perfect gas mixture *see* Ideal gas mixture
- Phase 47  
Amorphous 52  
Crystalline 52  
Definition 47  
Equilibrium 47  
Fluid 50  
Gas 50  
Liquid 50  
Liquid crystalline 53  
Metastable equilibrium 52  
Non-equilibrium 48  
Solid 52  
Stable equilibrium 52  
Vapor 51
- Phase boundary 58
- Phase diagram 266  
Binary 266  
Ternary 266
- Phase equilibrium 226, 228  
One-component 226, 228  
Two-component 235
- Phase rule; *see* Gibbs phase rule
- Phase separation 259, 261
- Phase transition 55, 57, 227–228
- Pitzer acentric factor 126
- Pitzer correlation for second virial  
coefficient 126
- Plait point 269
- Polyhedral foam *see* Foam
- Polymer molecular weight 319
- Positive azeotrope 291
- Poynting factor 247, 278
- Pressure 32  
Absolute 33  
Anisotropic 34  
Barometric 33  
Blood 35 *see also* blood pressure  
Critical 113  
Definition 32  
Gauge 33  
Gradient 33  
Hydrodynamic 33  
Hydrostatic 33  
Matrix 34  
Negative 121  
Normal 34  
Partial 35, 129 *see also* partial pressure  
Reduced 66  
Shear 34  
Spatial distribution 14–15  
Sublimation 34, 57  
Tensor 34  
Units 32–33  
Vacuum 33  
Vacuum gauge 33  
Vapor 34 *see also* vapor pressure

- Pressure–composition ( $P$ – $x$ – $y$ ) diagram 279
- Pressure measurement 32  
Bourdon gauge 33  
Dead weight tester 33  
Manometer 32–33
- Principle of corresponding states 125  
Principle of equipartition 98  
Principle of moderation 377  
Probability of energy state  
For canonical ensemble 332  
For microcanonical ensemble 331
- Quality, steam *see* Steam quality
- Quantum-mechanical state  
Of molecule 330  
Of system 330
- Quantum mechanics 329
- Radiation heat transfer *see* Heat, radiation
- Raoult's law 278, 286  
Modified 286
- Reaction equilibria  
Gas-phase reaction 381  
Gas-phase reaction, ideal gas 381  
Heterogeneous reaction 392  
Liquid-phase reaction 388  
For multiple reactions  
Yields from equilibrium constants 402  
Yields from minimization of Gibbs free energy 403  
Nonideal gas mixtures 387
- Reaction equilibrium constant 375  
Temperature dependence of 377
- Reaction kinetics 361
- Reaction mechanism 360
- Reactive system and phase rule 237
- Redlich–Kister equation 260
- Redlich–Kwong equation of state  
*see* Equation of state,  
Redlich–Kwong
- Reduced molar volume 125
- Reduced pressure 66
- Reduced temperature 66
- Reference state 257
- Reference chemical potential *see* Chemical potential, reference
- Refrigerator 194  
Efficiency  
Actual 196  
Ideal 195
- Regular solution model 260  
And activity coefficients 260  
Definition 260  
Enthalpy change on mixing 260  
Entropy change on mixing 260
- Gibbs free energy change on mixing 260  
Parameter 260
- Relative humidity 130
- Relative volatility 274
- Reservoir *see* Heat reservoir
- Resistance thermometer 64
- Reverse osmosis 322
- Reversible work 36–37, 83
- Rotational energy 72
- Saturated liquid 57
- Saturated vapor 57
- Scalar 32
- Second Law 5, 181, 185  
And absolute temperature 207  
And entropy 207  
Experimental basis 181  
First version 185  
Other versions 207
- Second Law of thermodynamics *see*  
Second Law 7.2
- Second partial derivative 77
- Second virial coefficient *see* Virial coefficient
- Selectivity *see* Relative volatility
- Semipermeable membrane 315
- Shaft work 70, 74
- Shock wave 49
- Simple thermodynamic phase 11, 61
- Smectic liquid crystal 54
- Solar energy 74
- Solid phase 52
- Solid–liquid equilibrium 56–57
- Solubility of gas in liquid 302
- Solubility of solid in a liquid 355
- Solubilization 309
- Solution  
Ideal 249  
Metastable 263  
Nonideal 249  
Stable 262
- Solution model 259  
Asymmetric 260  
Margules equation 260  
Redlich–Kister equation 260  
Regular 260  
Symmetric 260  
Unstable 262
- Solution nonideality parameter 321
- Specific heat *see* Heat capacity
- Specific property 61
- Spinodal 262  
Decomposition 263  
Definition 262  
For regular solution model 264  
Line 265
- Region 269  
Triangle 270
- Stability, thermodynamic *see*  
Thermodynamic stability
- Stage, of distillation column 275  
Actual number 281  
Ideal 275  
Minimum number of 275  
Theoretical 275
- State function 76
- Statistical mechanics 329
- Steam quality 127  
Experimental determination 170
- Steam tables 127  
Data 426  
Saturated steam 127  
Superheated steam 127
- Stoichiometric coefficient of reaction 362
- Stress 32  
Definition 32  
Normal 32  
Tensile 32  
Tensor 34
- Subcooled liquid 56
- Subcritical temperature 51
- Sublimation 57
- Sublimation pressure 57 *see* Pressure,  
sublimation
- Supercooled liquid 56
- Superheated vapor 57
- Supercritical fluid 51
- Supercritical fluid phase 51
- Surface 58
- Surface area 31
- Surface excess density *see* Excess surface  
density
- Surface tension 40, 59, 347
- Surface thermodynamics 10, 347
- Surroundings 74
- Sustainability 421
- System 74  
Adiabatic 74  
Batch 87  
Closed 74  
Effectively adiabatic 74  
Open 74, 84  
Semi-batch 87
- Tank emptying 170
- Tank filling 170
- Taylor series expansion and 318
- Temperature  
Absolute 62, 190  
Absolute zero 325  
Consolute 270  
Critical 51  
Empirical 62

- Ideal gas 62, 66
- Molecular significance 107
- Reduced 66
- Subcritical 51
- Thermodynamic 62, 190
- Temperature–composition ( $T$ - $x$ - $y$ ) diagram 282
- Tensor 34
- Ternary phase diagram 266
- Thermal equation of state 100, 205
- Thermal load 86
- Thermodynamic consistency *see* Consistency, thermodynamic
- Thermodynamic phase
  - Equilibrium 47
  - General definition 48
  - Metastable 56
  - Non-equilibrium 48
  - Stability of 261
  - Stable 56
  - Unstable 56
- Thermodynamic stability 261
- Thermodynamics 1
  - Axioms of 4, 47
  - Bases of 1
  - Hypotheses of 4
  - Laws of 4
  - Macroscopic aspects 3
  - Metrics of learning 12
  - Microscopic aspects 3
  - Molecular aspects 3
  - Postulates of 4, 47
  - Validity of 1
- Thermocouple 65
- Thermoelectric effect 65
- Thermometer 64
  - Mercury 62, 64
  - Resistance 64
- Thermostatics 5, 66
  - Liquid crystal *see* Liquid crystal, thermotropic
- Third Law 5, 328, 337
  - Experimental basis 327
  - Molecular basis of 337
- Third Law of thermodynamics *see* Third Law
- Three-phase system 270
- Three-phase triangle 270
- Tie-line 269
- Throttling process 166
- Total derivative *see* derivative
- Total energy 72
- Total work *see* Work, total
- Translational kinetic energy 72, 107
- Trinodal 270
- Triple point 57, 237
- Two-state function 245
- Units
  - Energy 39
  - Force 29
  - Length 27
  - Mass 28
  - Pressure 32–33
- Universal gas constant 19, 66, 336
- Universal gravitational constant 24 *see* Gravitational constant
- Unmixing 259
- Useful work 91 *see also* Shaft work
- Valence bond 358
- Validity of First and Second Laws 217, 228–229, 239, 377
- Van der Waals equation of state 112
- Van 't Hoff equation 377
- Vapor–liquid equilibrium VLE 57, 226, 258, 276, 294
- Vapor–liquid–liquid equilibrium or VLLE 276
- Vapor phase *see* Phase, vapor
- Vapor pressure 34, 56, 116
  - Antoine equation for 117
  - Data 425
  - Definition 116
  - Equation for 117–118
  - Measurement 57, 116
  - Method 350–351
  - Prediction 120
- Vector 27
- Velocity 31
- Vesicle 60
- Virial coefficient
  - First 123
  - Fourth 123
  - Second 123, 322
  - Third 123
- Volume 30
  - Change on mixing 131
  - Critical molar 113
  - Molar 137
  - Partial molar 131
  - Reduced 125
  - Specific 103
- Volume expansivity 104
- Water purification 322
- Watt or W 39
- Watt hour, or Wh 40
- Wet steam 127
- Work 73
  - Definition 35
  - Electrostatic 40
  - Differential 36
  - Irreversible 36, 76
  - Magnetostatic 40
  - Mechanical 35
  - Molecular basis 337
  - $p$   $dV$ -type 74
  - Reversible 76
  - Surface tension 40
  - Reversible 36–37
  - Shaft 74
- Yield stress 52
- $y$ - $x$  diagram 281–282
- Zeroth Law 4, 63, 67
  - And empirical temperature 4, 63
  - Statement 4, 63