

# Index

## A

- Abiogenic origin
  - evidence, 67
  - of petroleum, 48–50, 66–67
- Absorption, 713–715
  - liquid removal, 723
  - water removal, 720
- Acetylene, chemicals from, 799
- Acid catalyzed hydrogenolysis, kerogen, 92
- Acid gases, 711, 818–820; *see also* Acid gas removal
- Acid gas removal
  - Alkazid process, 727–728
  - amine absorption process, 725
  - in gas processing, 724–728
  - Giammarco-Vetrocoke process, 728
  - Girbotol process, 727
  - hydrogen sulfide, 724–725
  - iron oxide process, 725–727
  - molecular sieve process, 728
  - phosphate desulfurization process, 727
  - zinc oxide process, 727
- Acid processes
  - nalfining, 693
  - product treating, 691–694
  - sulfuric acid treatment, 693–694
- Acid rain, 810, 821, 830
  - concept of, 95
- Acid sludge, 760, 777
- Acid treatment
  - fractional composition of petroleum, 229–231
  - Marcusson-Eickmann fractionation procedure, 229
  - Rostler-Sternberg fractionation procedure, 230
- Activated clay, 222
- Additives, 544, 748–750
  - anti-icing, 749
- Adduct
  - composition, 232–233
  - properties, 234–235
  - structure, 233–234
  - thiourea adduction, 232
  - urea adduction, 231–232
- Adsorbents, 222–227
  - Adsorption method, 713–714
    - fractional composition of petroleum, 222–229
    - chemical factors, 222–223
    - fractionation methods, 223–229
  - Advanced extraction technology (AET) process, 723–724
  - Advanced partial conversion uncracking (APCU) process, 626–627
  - Airlift thermofor catalytic cracking, 529
  - Albertite asphaltoids, 19
  - Alicyclic hydrocarbons, 822
  - Aliphatic compounds, 787
  - Alkaline flood processes, 121, 126, 134, 143
  - Alkaline permanganate oxidation, kerogen, 90–91, 93
  - Alkazid process, for acid gas removal, 727–728
  - Alkylation
    - effluent treatment process, 694
    - processes, 10, 446, 488, 569
      - cascade sulfuric acid, 678–679
      - catalysts, 424, 683
      - historical development, 423
      - hydrogen fluoride, 679, 681
      - modern development, 423–424
      - product improvement, 677–679, 681
      - refining processes, 423–424
  - Alternate energy sources, 808
  - Alumina ( $g\text{-Al}_2\text{O}_3$ ) catalysts, 591, 593
  - Alumina guard beds, 721
  - Alumina-silica ( $\text{Al}_2\text{O}_3\cdot\text{SiO}_2$ ) catalyst, 682, 686
  - Aluminum chloride catalyst, 675, 683
  - Aluminum soap, 768
  - American Petroleum Institute (API)
    - gravity, 35, 68
    - petroleum classification by, 37–38, 40
  - American Society for Testing and Materials, 231
  - Amine absorption process, for acid gas removal, 725
  - Amine (olamine) process, 849
  - Amoenitates Exoticae*, 8
  - Anticline, 60, 62–63
  - Anti-icing additives, 749
  - Antiknock compounds, 749
  - API gravity, *see* American Petroleum Institute gravity

- Aquaconversion, 507
- Aromatics, 14–15, 25, 35, 315, 345–346  
 antiknock characteristics, 745  
 chemicals from, 797–799  
 compounds, 787, 822  
 extraction using furfural, 702  
 fraction, crude oil, 205, 222–223
- Arosorb process, 694, 752
- Asphalt, 3–6, 14, 22–23, 733–735, 737, 771–775, 827  
 composition, 771–772  
 linguistic origins, 4–8  
 manufacture, 772–774  
 properties and uses, 774–775  
 test methods used to determine properties, 775
- Asphalt-base crude oil, 466
- Asphalt coking technology (ASCOT) process, 507–508
- Asphaltene, 14, 24–25  
 coking, 448  
 fraction, 15  
 crude oil, 205  
 separation, 455  
 fractional composition of petroleum, 216–220  
 influence of contact time, 220  
 influence of solvent type, 216–219  
 influence of temperature, 219  
 solubility parameter, 454  
 thermal decomposition, 450  
 and wax deposition, 147
- Asphaltene constituents, 315–341  
 composition, 319–324  
 molecular weight and polarity basis, 322  
 functional group composition, 317  
 molecular weight, 324–328  
 by cryoscopic method, 325  
 dielectric constant of solvent influence on, 326  
 by size exclusion chromatography, 325  
 by small-angle neutron scattering, 325  
 by specific viscosity of asphaltene solutions, 327  
 by vapor pressure osmometry, 325
- precipitation methods, 316, 318, 356–357, 364
- reactions, 328–333  
 facile reactions, 330, 332  
 halogenation, 330–331  
 metal chlorides, 331–332  
 oxidation, 329–330  
 phosphorylation, 332  
 with sulfur, 332  
 thermal decomposition, 328–329
- sediment formation and deposition, 350, 360
- separation, 316–319  
 parameters, 317–318
- solubility parameter, 333–335, 357–358, 362–363  
 hydrogen-carbon ratios based, 334, 363
- structural aspects, 335–341
- thermolysis, 367–368
- Asphaltenic bottom cracking (ABC) process, 610
- hydrocracking, 610–611
- Asphaltic pyrobitumen, 18
- Asphaltite, 14, 18
- Asphaltoids, 14, 18–19
- Asphalt residual treating (ART) process, heavy feedstocks, 530–531
- Associated gas, 707
- Associated natural gas, 74–75
- Atmospheric distillation, 10, 401–403, 468–473, 547, 832–833  
 column, parts of, 476  
 fractional composition of petroleum, 210–211  
 tower, temperature profiles within, 471
- Atmospheric equivalent temperatures (AET), 212
- Atmospheric residua, properties, 772
- Atmospheric residuum, 522, 534
- Autofining process, hydrotreating and desulfurization, 584
- Aviation gasoline, 745
- Azeotropic and extractive distillation, 405
- Azeotropic distillation, 481–482  
 fractional composition of petroleum, 213–214
- Azeotropic entrainer, 482
- ## B
- Barisol dewaxing, 564, 704
- Barium soaps, 767
- Bauxite, 530  
 treatment process, 694–695
- Beaven process, 852–853
- Bender process, 696
- Benzene, 15  
 chemicals from, 797–798
- Benzene-acetone solvent dewaxing, 704
- Benzene-toluene-ethylbenzene-xylene (BTEX)  
 analysis method, 874, 879
- Biodegradation and water washing, 66
- Biodesulfurization, 594–596
- Biogenic origin  
 evidence, 67  
 of petroleum, 50–66  
 abiogenic origin theories and, 66–67  
 accumulation in reservoir sediments, 58–63  
 deposition of organic matter, 52  
 establishment of source beds, 52–54

- source material, 54–57
- transformation of organic matter into petroleum, 57–58
- in situ* transformation of petroleum, 63–66
- Bitumen, 3–8, 14, 16–17, 64, 76–79; *see also* Heavy oil and bitumen
- linguistic origins, 4–8
- Bituminous mortar, 7
- Bituminous residue, 51, 61
- Bituminous rock, 19
- Bituminous sand, 16–17, 19, 77
- Blending of products, 777–778
- Blown asphalt, 475
- Bogging, 505
- Boiling point, classification petroleum by, 42
- Borehole logging methods
  - acoustic logging, 105
  - density logging, 105
  - electrical logging, 105
  - petroleum exploration, 105–106
  - radioactive logging, 105
- Bright stock, 763
- Brønsted acids, 630
- Bubble cap, 472
  - trays, 477
- Bulk acid polymerization, 681–682
- Bunker C oil, 854, 863
- Burton cracking process, 492
- Butamer process, isomerization, 675
- Butane
  - isomerization, 421–422, 674
  - properties, 738
- Butomerate process, isomerization, 675–676
- C**
  - Cable tool system, drilling operation, 106
  - Calcining, 537
  - Calcium soaps, 767
  - CANMET hydrocracking process, hydrocracking, 610–612
  - Carbenes, 14, 24–25, 351, 450
  - Carbohydrates, 55
  - Carboids, 14, 24–25, 351, 450
  - Carbon dioxide (CO<sub>2</sub>), 531
    - immiscible flooding, 143
    - miscible flooding, 127–128, 134, 143
  - Carbon distribution, classification petroleum by, 39
  - Carbon mobilization (CM), 605
  - Carbon rejection processes, 430, 457, 574, 602
  - Cascade sulfuric acid alkylation, 678–679
  - Casing head gas, 21, 74, 114
  - Catagenesis, 50–51
  - Catalyst(s)
    - alkylation processes, 424, 683
    - catalytic cracking, 537–538
      - demet, 538
      - met-X, 538
    - catalytic methods, 414–415
    - hydrocracking, 599, 628–634
    - hydrogen production, 653–655
    - hydrotreating and desulfurization, 590–594
    - isomerization processes, 422–423, 683
    - methanation, 655
    - poisoning, 653, 699
    - polymerization processes, 425, 683–684
    - product improvement, 682–684
    - reforming processes, 420–421, 653–654, 682–683
      - shift conversion, 654–655
      - variables, 542–543
  - Catalytic cracking, 440–442, 488, 521–544, 817
    - airlift thermofor, 529
    - carbonium ions role in, 441–442
    - catalysts, 537–538
    - commercial processes, 525–536
      - fixed-bed processes, 526
      - fluid-bed, 526–529
      - moving-bed, 529–530
      - options heavy feedstocks, 530–536
    - early processes, 525
    - fluid-bed catalytic cracking, 526–528
    - fluid-bed processes, 526–529
    - historical development, 521–525
    - houdresid catalytic cracking, 529
    - houdriflow catalytic cracking, 529
    - mechanisms, 441–442
    - model IV fluid-bed catalytic cracking unit, 528
    - moving-bed processes, 529–530
    - orthoflow fluid-bed catalytic cracking, 528
    - principles of, 438
    - processes, 10, 397–398, 412–414, 639, 709, 781
    - process parameters, 538–544
      - additives, 544
      - catalyst variables, 542–543
      - coking, 540–542
      - process variables, 543–544
      - reactor, 539–540
    - shell two-stage fluid-bed catalytic cracking, 528
    - socony airlift TCC process, 529
    - suspensoid catalytic cracking, 529–530
    - universal oil products fluid-bed catalytic cracking, 528–529
  - Catalytic desulfurization processes, 820
  - Catalytic dewaxing
    - for manufacture of lubricating oil, 761
    - processes, 10, 705–706

- Catalytic distillation, 485
- Catalytic hydrodesulfurization, 640
- Catalytic hydrotreating, 640
- Catalytic isomerization process, 10
- Catalytic methods
  - catalysts, 414–415
  - historical development, 411–413
  - modern development, 413–414
  - refining processes, 411–415
- Catalytic oxidation, 713
- Catalytic polymerization process, 10
- Catalytic reformer off-gas, 643, 659
- Catalytic reformer product gas, 667
- Catalytic reforming processes, 10, 419–420, 488, 645, 672–673, 782, 819
  - fixed-bed processes, 668–672
  - fluid-bed processes, 672–673
  - moving-bed processes, 672
  - product improvement, 665–673
- Catforming process, 670
- Caustic processes
  - Dualayer distillate, 689
  - Dualayer gasoline, 689
  - electrolytic mercaptan, 689
  - ferrocyanide, 689
  - lye treatment, 689–690
  - mercapsol, 690
  - polysulfide treatment, 690
  - product treating, 688–691
  - sodasol, 690–691
  - solutizer, 691
  - steam regenerative caustic treatment, 691
  - unisol, 691
- Centrifuge dewaxing, 705
- Ceresin, 22
- Cetane number, 758
- Chaos theory, 355
- Chemical composition, classification
  - petroleum by, 34–36
- Chemical desalting, 831
- Chemical factors, in fractional composition of petroleum, 222–223
- Chemical method, fractional composition of petroleum, 229–235
- Chemical process industry, 784
- Chemical refining processes, 760
- Chemical substances, 814
- Chemical wastes, 810
- Chemisorption, 713
- Cherry-P process, 508–509
- Chlordane, 766
- Chlorex, 701
- CHOPS, *see* Cold heavy oil production with sand technology
- Christmas tree, 99, 111, 114
- Chromatographic data, classification of petroleum by, 42
- Chromia-alumina ( $\text{Cr}_2\text{O}_3\text{-Al}_2\text{O}_3$ ) catalyst, 682
- Chromic acid oxidative degradation, kerogen, 91, 93
- Chromium, 530
- Chromium oxide ( $\text{Cr}_2\text{O}_3$ ), 654
- Chromium sulfide ( $\text{Cr}_2\text{S}_3$ ), 629
- Clastic reservoirs, 43–44
- Claus process, 852–853
  - in gas processing, 729–731
- Clay processes
  - alkylation effluent treatment, 694
  - arosorb, 694
  - bauxite treatment, 694–695
  - continuous contact filtration, 695
  - cyclic adsorption, 695
  - gray clay treatment, 695
  - percolation filtration, 695
  - product treating, 694–696
  - thermoform continuous percolation, 695–696
- Clays, 440–441, 530, 629
- Clean Air Act Amendments of 1990, 812
- Clean Air Act of 1970, 812, 814–815
- Clean Water Act, 812, 814–815
- Coal, 14
- Coal tar, 23
  - pitch, 23
- Cobalt, 530, 591
- Cobalt-molybdenum-alumina catalysts, 573
- Cobalt-molybdenum (Co-Mo) catalysts, 573, 591, 593, 634, 667
- Cobalt sulfide (CoS), 629
- Coil visbreaking process, 495–496
- Coke, 14, 24, 398, 735, 774, 776
  - formation, 369–370, 442, 448, 450, 452–454, 456, 491, 540–542, 644, 653–654
- Coking, 397, 401, 407, 451, 488, 540–542, 817
  - processes, 10, 499–506, 709
  - delayed coking, 500–503
  - flexicoking, 505–506
  - fluid coking, 503–505
  - thermal methods, 409–412
- Cold heavy oil production with sand (CHOPS) technology, 163–164, 167–169
- Cold pressing, 762
- Cold sett grease soap, 768
- Cold-water process, 155

- Column distillation, 209
  - Combined cycle power generation, hydrogen production, 646–647
  - In situ* combustion, 143
    - heavy oil and bitumen recovery by, 160–163
    - recovery of oil, 132–134
  - Combustion gases, 531
  - Combustion processes, 160–163
    - in situ* combustion, 160–162
    - forward combustion, 161
    - heavy oil and bitumen recovery by, 160–163
    - reverse combustion, 161–162
  - Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 814–815, 858
  - Comprehensive Heavy Ends Reforming Refinery process, *see* Cherry-P process
  - Contingent resources, 71–72
  - Continuous catalyst regeneration (CCR)
    - configuration, 667
  - Continuous contact filtration process, 695
  - Conventional petroleum, 70–74
  - Conventional recovery, *see* Primary oil recovery
  - Conversion processes, 438–439, 604–605
    - refining, 397
    - relationship to hydrogen pressure, 606–607
  - Conversion refinery, 398
  - Copolymerization, 447
  - Copper sweetening process, 696–697
  - Correlation index, classification of petroleum by, 36–37
  - Corrosion inhibitors, 749
  - Cracked oil, 510
  - Cracking, 405, 439–443
    - catalytic cracking, 440–442
    - dehydrocyclization, 443
    - dehydrogenation, 443
    - reaction occur during, 439
    - thermal cracking, 439–440
  - Crankcase oil, 758, 864
  - Critical micelle concentrations (CMC), 358–359
  - Crude oils, 8, 12; *see also* Petroleum classifications, 466 constituents, 315 elements, 395 enrichment, 728 extraction of, drilling for, 106–110 fractions, 205
    - aromatics, 205
    - asphaltene, 205
    - resin fraction, 205
    - saturates, 205
    - high-sulfur, 53
    - high-wax, 53
    - nature of, 53
    - properties, 77
    - reservoirs
      - gas cap, 112, 114–115
      - gravity drainage, 117
    - trends for sulfur removal, 603–604
  - Crude petroleum, generic boiling fractions, 396
  - Crude xylene stream desorbent, 694
  - Cryogenic separation, hydrogen purification, 658
  - Cutback asphalt, 753, 774
  - Cyclic adsorption process, 695
  - Cyclic steam injection (huff and puff), 130–131, 159–160
  - Cyclization, 51, 58
  - Cyclone collectors, 717
  - Cycloparaffins, 35
  - Cycloversion process, 683
- ## D
- DAO, *see* Deasphalted oil
  - DDT, 766
  - Deasphalted oil (DAO), 547
  - Deasphalted oil, 347
  - Deasphalter bottoms, 547
  - Deasphalter tar, 547
  - Deasphalting processes, 10, 65–66, 215, 316, 484, 522, 547–562, 699–700
    - deep solvent deasphalting, 550, 555–558
  - Demex, 558–559
    - heavy feedstocks, 550, 554–561
    - lube deasphalting, 561
    - MDS process, 559–560
    - residuum oil supercritical extraction, 560–561
    - Solvahl, 561–562
    - solvent, 425–426
  - Debutanizer, 480
  - Decarbonizing, 509, 699
  - Deep solvent deasphalting process, 550, 555–558
  - Dehydrocyclization, 443, 524, 667
  - Dehydrogenation, 443, 667–668
  - Delayed coking, 401, 410, 457, 494, 500–503, 817, 836–837
    - visbreaking, 495
  - Demetallation, 522
  - Demetallization reactors, 583
  - Demex deasphalting process, 557–559
  - Demulsifiers, 749
  - Denitrogenation, 686
  - Density (specific gravity), petroleum classification by, 37–38

- Depentanizer, 480
  - Depropanizer, 480
  - Derived materials
    - aromatics, 14, 25
    - asphaltenes, 14, 24–25
    - carbene, 14, 24–25
    - carboid, 14, 24–25
    - oils, 25
    - resins, 14, 25
    - saturates, 14, 25
  - Desalting, refining processes, 398–399
  - Desorption, 537, 713
  - Destructive hydrogenation, 415, 569
  - Desulfurization processes, 429, 685–686; *see also*
    - Hydrotreating and desulfurization
  - Dewatering and desalting, refining processes, 398–399
  - Dewaxing processes, 562–566, 703–706
    - solvents, 426–427
  - Diagenesis, 50–51
  - Diatomaceous earth, 831
  - Diesel fuel oil, 3, 397–398, 438, 490, 661, 756–758, 827
  - Diesel fuel polishing, hydrotreating and desulfurization, 594–595
  - Diesel oil deep desulfurization (DODD) process, 586
  - Diesel range organics (DRO), 865
  - Diethanolamine (DEA), 715, 725
  - Diethylene glycol (DEG), 720
  - Differential wetting phenomenon, 89
  - Diglycolamine (DGA), 715
  - Diisopropanolamine (DIPA), 715
  - Di-Me dewaxing process, 761
  - Directional drilling, 113
  - Discovered petroleum-initially-in-place, 71
  - Displacement efficiency, 118
  - Dissolved natural gas, 74
  - Distillate(s), 14
    - fuel oil, 756
    - hydrocracking (DHC), 610
    - hydrodesulfurization, 641
    - hydrotreating, 576
  - Distillation, 465–485
    - atmospheric, 210–211, 402–403, 468–473
    - azeotropic, 213–214, 481–482
      - and extractive distillation, 405
    - column, 209
    - equipment, 475–478
      - columns, 475–477
      - packings, 477
      - trays, 472, 477–478
    - extractive, 213–214, 483–484
    - fractional composition of petroleum, 207–214
      - atmospheric distillation, 210–211
      - azeotropic distillation, 213–214
      - extractive distillation, 213–214
        - reduced pressure distillation, 211–213
      - historical development, 401–402
      - modern development, 396, 402–405
      - pretreatment, 467–468
      - process options for heavy feedstocks, 484–485
      - reduced pressure distillation, 211–213
      - refining processes, 400–405
      - rerunning, 479
      - short-path distillation, 209
      - stabilization and light end removal, 479–480
      - stripping, 478–479
      - superfractionation, 480–481
      - vacuum distillation, 396, 403–405, 468–475
  - Doctor process, 697
  - Domestic fuel oil, 756
  - Downflow fixed-bed reactor, 576, 581–582
  - Draglines and bucket-wheel reclaimers, 152
  - Drag reducers, 749
  - Drilling operation
    - cable tool system, 106
    - drilling, 109–110
      - rig, 107–109
      - rig components, 107, 109
    - oil extraction, 106–110
    - preparation to drill, 106
  - Drilling wells, 143
  - Dry cleaning, 753
  - Dry natural gas, 74
  - Dualayer distillate process, 689
  - Dualayer gasoline process, 689
  - Duo-Sol process, 561, 689, 700–701
  - Dyes, 749
- E**
- Edeleanu process, 701, 752
  - Elaterite asphaltoids, 19
  - Electrical methods, exploration for petroleum, 104
  - Electrochemical oxidation and reduction,
    - kerogen, 93
  - Electrolytic mercaptan process, 689
  - Electromagnetic methods, exploration for petroleum, 104–105
  - Electrostatic desalting, 831–832
  - Emergency Planning and Community Right-to-Know Act (EPCRA), 814
  - Emission control processes
    - amine washing, 715
    - carbonate washing, 715
    - solvents used for, 714–715
  - Emulsion flooding, 122, 134, 143

- Energy production, environmental regulations to, 815
- Energy reserves, definitions, 79
- Energy resources
  - distribution of, 26, 47–48
  - of future, 44–45
- Enhanced oil recovery (EOR) methods, 99, 119–133, 143–146, 156
- Enriched gas, 119
- Environmental analysis, 861–880
  - assessment of methods, 877–880
  - leachability, 864
  - petroleum and petroleum products, 862–864
  - petroleum fractions, 877
  - refineries, 861–880
  - total petroleum hydrocarbons (TPH)
    - assessment of methods, 877–880
  - toxicity, 864
- Environmental Protection Agency, 854, 858
- Environmental Protection Agency Inventory of Chemical Substances, 813
- Equipment for distillation, 475–478
  - columns, 475–477
  - packings, 477
  - trays, 477–478
- Ethylene
  - chemicals from, 788
  - dichloride-benzene dewaxing, 704
- Ethyl tributyl ether (ETBE) synthesis, 485
- ET-II process, 510–511
- Eureka process, 510–512
- Evolutionary pathways, kerogen, 84, 87
- In situ* extraction processes, 149
- Extractive distillation, 405, 481, 483–484
  - fractional composition of petroleum, 213–214
  - process, 752
  - solvent selection criteria, 483–484
- Extra heavy oil, 76–79
- Exxon Dilchill dewaxing process, 761
- F**
- Fabric filters, 717–718
- Fat oil, 480, 723
- Fats, 55
- Fatty acids, 54
- FCC, *see* Fluid catalytic cracking
- Feedstock conversion (FC), 605
- Feedstock cracking, indications of, 448–449
- Feedstocks hydrogen production, 642–643
- Ferric oxide (Fe<sub>2</sub>O<sub>3</sub>), 654
- Ferrocyanide process, 689
- Ferrofining process, hydrotreating and desulfurization, 584
- Finishing processes, 438, 761–762
- Fireflood-waterflood (COFCAW) process, oil recovery, 133
- Fischer-Tropsch process, 597, 654
- Fixed-bed processes, 521, 525, 667
  - catalytic cracking, 526
  - catalytic reforming, 668–672
- Flexicoking process, 10, 412, 457, 505–506, 817
- Floating tension leg platforms, 113
- Flocculation threshold, 614
- Fluid-bed catalytic cracking, 526–528
- Fluid-bed processes, 525, 667
  - catalytic cracking, 526–529
    - fluid-bed catalytic cracking, 526–528
    - model IV fluid-bed catalytic cracking unit, 528
    - orthoflow fluid-bed catalytic cracking, 528
    - shell two-stage fluid-bed catalytic cracking, 528
    - universal oil products fluid-bed catalytic cracking, 528–529
  - catalytic reforming, 672–673
  - catforming, 670
  - hydroforming, 668
  - iso-plus houdriforming, 669
  - platforming, 669–671
  - powerforming, 671
  - reforming, 671
  - selectoforming, 671–672
- Fluid catalytic cracking (FCC), 507, 588, 609, 831
  - unit, 414
- Fluid coking, 401, 410–411, 457, 503–505, 817, 836–837
  - visbreaking, 495
- Fluid thermal cracking (FTC) process,
  - see* FTC process
- Fossil fuels, 47–48
- Fossil fuel usage, 3
- Fractional composition of petroleum
  - adsorption, 222–229
    - chemical factors, 222–223
    - fractionation methods, 223–229
  - chemical methods, 229–235
    - acid treatment, 229–231
    - molecular complex formation, 231–235
  - chromatographic technique, 223–224
  - distillation, 207–214
    - atmospheric distillation, 210–211
    - azeotropic distillation, 213–214
    - extractive distillation, 213–214

- reduced pressure distillation, 211–213
  - solvent treatment, 214–222
    - asphaltene separation, 216–220
    - fractionation, 220–222
    - studies, 235–236
  - Fractional distillation, *see* Distillation
  - Fractionation methods, 724
    - all-solvent methods, 221–222
    - ASTM method, 227–229
    - elution technique, 224
    - fractional composition of petroleum, 223–229
    - in gas processing, 728–729
    - SARA method, 225–226
    - USBM-API method, 225–226
    - use of solvents, 221–222
  - Fractionation solvent treatment, fractional composition of petroleum, 220–222
  - Fracture-assisted steam technology (FAST) process, 162
  - FTC process, 511, 513
  - Fuel oils, 3, 397, 736, 756–758, 827
  - Functional groups analysis, kerogen, 90, 94
- G**
- Gas
    - production by thermal processes, 782
    - recovery by distillation, 782
  - Gas cap, 62, 112, 114–115
  - Gas chromatographic methods, 874–875
    - petroleum and petroleum products, 866–869
  - Gas chromatography-mass spectrometry, 876–877
    - kerogen, 92
  - Gas cleaning, processing, 712–719
  - Gas condensates, 75
  - Gaseous emissions, environment aspect, 818–822
  - Gaseous fuels, 733, 738–742
    - composition, 738–739
    - manufacture, 739
    - properties and uses, 739–742
  - Gasflood, 118
  - Gas-liquid chromatography (GLC), 874
  - Gasohol, 748
  - Gas oil, 437
  - Gasoline, 3, 397–399, 408, 411, 413, 437–439, 487–488, 490, 492, 521, 583, 639, 661, 680–681, 692
    - additives, 748–750
    - blending, 778
    - component streams for, 422
    - composition, 742–743
    - fuel polishing
      - hydrotreating and desulfurization, 594–595
      - manufacture, 743–746
    - octane numbers, 740–741, 746–748
    - oxygenates in, 663–664
    - production, 569–570
    - properties and uses, 746
    - range organics (GRO), 865
    - refinery streams produce, 744
  - Gas processing, 707–731
    - acid gas removal, 724–728
      - Claus process, 729–731
      - from crude oil, 708–711
      - enrichment, 728
      - factors to be considered, 712–713
      - fractionation, 728–729
      - gas cleaning, 712–719
      - liquids removal, 722–724
        - absorption, 723–724
        - extraction, 722–723
        - fractionation of natural gas liquids, 723–724
      - from natural gas, 711–712
      - nitrogen removal, 724
      - olamines use in, 716
      - water removal, 719–722
        - absorption, 720
        - solid adsorbents, 720–721
        - use of membranes, 721–722
    - Gas reversion, 665
    - Gas streams
      - from crude oil, 708–711
      - gas processing, 708–712
      - from natural gas, 711–712
    - Geochemical carbon cycle, 3
    - Geological timescale, 49
    - Geophysical borehole logging, 101
    - Giammarco-Vetrocoke process, for acid gas removal, 728
    - Gilsonite, 18
    - Girbotol process, for acid gas removal, 727
    - Girdler process, 849–850
    - Glance pitch, 18
    - Global warming, 822
    - Glycol, refrigeration process, 719
    - Grahamite, 18
    - Gravimetric methods, petroleum and petroleum products, 870–871
    - Gravity drainage, crude oil reservoirs, 117
    - Gravity-driven processes, 163
    - Gravity methods, exploration for petroleum, 101–102
    - Gray clay treatment process, 695
    - Grease
      - aluminum soap, 768
      - cold sett grease soap, 768
      - lime soap, 766–768
      - lithium and barium soap, 768
      - soda soap, 768



- Greek fire, 8–9
- Greenhouse effect, 822
- Greenhouse gases, 651, 821
- Guard bed reactor, 583
- Gulf-HDS process, hydrotreating and desulfurization, 584
- H**
- Hazardous and Solid Waste Amendments of 1984 (HSWA), 858
- Hazardous Material Transportation Act, 815
- Hazardous waste, 810
- Heavy coker gas oil (HCGO), 500
- Heavy crude oil, distribution of products from, 735
- Heavy feedstocks
- catalytic cracking processes options, 530–536
    - asphalt residual treating, 530–531
    - heavy oil treating, 532
    - reduced crude oil conversion, 533–535
    - residue fluid catalytic cracking, 531–532
  - R2R process, 533–534
  - Shell FCC process, 534–536
  - S&W fluid catalytic cracking, 536–537
- deasphalting process, 554–562
- deep solvent deasphalting, 555–558
  - Demex, 557–559
  - lube deasphalting, 561
  - MDS process, 559–560
  - residuum oil supercritical extraction, 560–561
  - Solvahl, 561–562
- deep solvent deasphalting process, 555–558
- demex deasphalting process, 557–559
- distillation processes options, 484–485
- process concepts and configurations for refining, 430
- refining processes, 427–431
- thermal cracking processes options, 507–518
- aquaconversion, 507
  - asphalt coking technology, 507–508
  - Cherry-P process, 508–509
  - decarbonizing, 509
  - ET-II process, 510–511
  - Eureka process, 510–512
  - FTC process, 511, 513
  - HSC process, 512, 514–515
  - mixed-phase cracking, 515
  - naphtha cracking, 515
  - selective cracking, 515
  - shell thermal cracking, 515–517
  - Tervahl-T process, 517–518
  - vapor-phase cracking, 518
- Heavy feedstocks options
- hydrocracking, 610–628
  - hydrotreating and desulfurization, 473, 587–590
  - residfining process, 589–590
  - residuum desulfurization process, 473, 588–589
  - vacuum residuum desulfurization process, 473, 588–589
- Heavy fuel oils, 3, 14, 16, 76, 489, 756–757
- Heavy gas oil, 474
- Heavy oil and bitumen, 143–173
- mining methods, 150–157
    - cold-water process, 155
    - enhanced oil recovery method, 156
    - hot-water process, 152–155
    - sand-reduction process, 155
    - solvent extraction process, 155–156
    - tar sand mining, 150–152
  - nonmining methods, 157–173
    - cold heavy oil production with sand (CHOPS) technology, 163–164, 167–169
    - cold production, 163
    - combustion processes, 160–163
    - gravity-driven processes, 163
    - horizontal well technology, 163–164
    - inert gas injection (IGI), 163–165, 169
    - microbial enhanced oil recovery (MEOR) processes, 169–173
    - pressure pulse flow enhancement technology, 163, 168–169
    - steam-assisted gravity drainage (SAGD), 163, 165–167
    - steam-based processes, 159–160
    - vaporassisted petroleum extraction (VAPEX), 163, 168–169
- recovery of, 143–173
- Heavy oil treating (HOT) process, heavy feedstocks, 532
- Heavy residue gasification, hydrogen production, 646–647
- Heisenberg uncertainty principle, 355
- Heterogeneous azeotropes, 481
- Heterogeneous azeotropic distillation, 481
- High conversion soaker cracking (HSC) process, *see* HSC process
- High-octane polymer gasoline, 681
- High-performance liquid chromatography (HPLC), 872, 875–876
- H-oil process, 589–590, 606
- hydrocracking, 612–614
- Homogeneous azeotropes, 481
- Homogeneous azeotropic distillation, 481
- Horizontal well technology, 163–164
- Horsehead pump, 99, 117–118
- HOT process, *see* Heavy oil treating process

- historical development, 421–422
  - importance of, 445
  - isomerate process, 676
  - modern development, 421–422
  - of olefins, 446
  - of paraffins, 445
  - processes, 10, 445, 569, 673–677
    - butamer, 675
    - butomerate, 675–676
    - catalysts, 683
    - hysomer, 676
    - Iso-Ke, 676
    - isomate, 676
    - isomerate, 676
    - penex, 676
    - pentafining, 677
    - product improvement, 673–677
    - refining processes, 421–423
  - Iso-plus houdriforming process, 669
- J**
- Jet fuel, 397–398, 437–438, 487, 755, 827, 863
- K**
- Kerogen, 14, 19
    - bitumen, 85
    - characteristics of, 86–87
    - classification, 87–88
    - composition, 86–87
    - containing shales, 85
    - evolutionary pathways, 84, 87
    - formation, 84
    - isolation, 88–89
      - acid demineralization of shale, 89
      - sink-float methods, 89
    - laboratory heating studies, 95–96
    - laboratory-simulated evolution, 96
    - low-temperature maturation of, 96
    - maturation, 94–96, 320
    - occurrence, 83
    - organic constituents, 83
    - petroleum formation from, 84–85
    - properties, 83–87
    - structure
      - acid-catalyzed hydrogenolysis, 92
      - alkaline permanganate oxidation, 90–91, 93
      - chromic acid oxidative degradation, 91, 93
      - electrochemical oxidation and reduction, 93
      - functional groups analysis, 90, 94
      - gas chromatography-mass spectrometry, 92
      - micropyrolysis-mass spectrometry studies, 93
      - models, 92–94
      - nitric acid oxidation, 91
      - oxidation, 90–91
      - ozone, oxygen and H<sub>2</sub>O<sub>2</sub> oxidative degradation, 91
      - thermal method, 91–92
      - ultimate elemental analysis, 89–90
      - X-ray diffraction techniques, 93
    - structure of, 89–92
    - type I, 83, 87, 96
      - characteristics of, 86, 88
    - type II, 83, 96
      - characteristics of, 87–88
    - type III, 83, 87, 96
      - characteristics of, 87–88
    - type IV, 83, 87, 96
      - characteristics of, 87–88
    - types of, 86–88, 96
  - Kerosene, 3, 9, 11, 210, 395, 399–400, 402, 405–407, 437, 439, 465, 481, 487–488, 492, 661, 736–738, 754–756, 827
    - composition, 755
    - manufacture, 755–756
    - properties and uses, 756
  - Kerosine, *see* Kerosene
  - Kieselguhr (diatomaceous earth), 681
- L**
- Laxative oils, 765
  - LC-finishing processes, 589–590
    - hydrocracking, 617–619
  - Leachability, petroleum and petroleum products, 864
  - Lean absorption oil, 723
  - Lean gas, 21, 74
  - Lean oil, 480
  - Lewis acids, 630
  - Light crude oil
    - distribution of products from, 735
    - reserves, 47
  - Light ends, 479
  - Light gas oil, 210
  - Light hydrocarbons, 479
  - Light oils, 693
    - machine, 475
  - Light refinery gas, 643, 653
  - Lignin, 55, 84
  - Lime mortar, 7
  - Lime soap, 766–768
  - Lindane, 766
  - Liquefied natural gas (LNG), transportation, 138–139
  - Liquefied petroleum gas (LPG), 74, 76, 119, 398, 437, 532, 642, 729, 783, 827

- Liquid emissions environment aspect, 822–823
- Liquid-liquid phase separation, 452
- Liquids removal
  - absorption, 723–724
  - extraction, 722–723
  - fractionation of natural gas liquids, 723–724
  - gas processing, 722–724
- Lithium soaps, 767
- Low energy deasphalting (LEDA) process, 507, 555–556
- Low-temperature maturation of kerogen, 96
- Lube deasphalting process, 561
- Lube hydrofining, 585–586
- Lube-oil
  - hydrofining, 585
  - hydrotreating, 577, 640
- Lubricating oils, 14, 474, 554, 692, 733, 758–764, 827
  - composition, 759
  - manufacture, 759–764
  - properties and uses, 763–764
  - solvent extraction processes principle, 701
  - viscosity, 764
- Lye treatment process, 688–690
- M**
- Magnetic methods, exploration for petroleum, 102–103
- Magnetite ( $\text{Fe}_3\text{O}_4$ ), 654
- Mahogany acids, 765
- MAKfining process, hydrocracking, 619–620
- Maltenes (malthenes), 25, 319
- Manganese nodules, 530
- Manufacture, lubricating oil, 759–764
  - catalytic dewaxing, 761
  - chemical refining processes, 760
  - finishing processes, 761–762
  - hydroprocessing, 760
  - older processes, 762–763
  - solvent dewaxing, 761
  - solvent refining processes, 760–761
- Manufactured materials
  - asphalt, 14, 22–23
  - coke, 14, 24
  - distillates, 14
  - lubricating oils, 14
  - pitch, 14, 23–24
  - residuum, 14, 22
  - synthetic crude oil, 14, 24
  - tar, 14, 23–24
  - wax, 14, 22
- Markers, 749
- M-Coke process, *see* Microcat-RC process
- MDS deasphalting process, 559–560
- Membrane systems, hydrogen purification, 658
- MEOR, *see* Microbial enhanced oil recovery processes
- Mercaptol process, 690
- Mercaptans (R-SH), 685
- Mercox process, 698
- Mesophase, 491
- Metagenesis, 50–51, 96
- Methanation catalysts, 655
- Methane, chemicals from, 800
- Methoxychlor, 766
- Methyldiethanolamine (MDEA), 715
- Methyl t-butyl ether (MTBE)
  - oxygenate, 663–664, 749–750, 874
  - synthesis, 485
- Micellar flooding, 121–122, 134, 143
- Microactivity test (MAT), 543
- Microbial enhanced oil recovery (MEOR)
  - processes, 169–173, 594
- Microcat-RC process, hydrocracking, 619–620
- Microcrystalline waxes, 563, 769
- Microemulsion flooding, 121–122, 134, 143
- Micropyrolysis-mass spectrometry studies, kerogen, 93
- MIDW process, 565
- Mild hydrocracking process, 621–622
- Mild lube hydrotreating, 577
- Mineral oils, 758, 864
- Mineral wax, *see* Wax
- Miscible fluid displacement, 126, 134
- Missouri tar sands, 132
- Mixed-base crude oil, 466
- Mixed-phase cracking, 515
- Mobil distillate dewaxing (MDDW)
  - process, 565
- Mobility ratio, 121
- Model IV fluid-bed catalytic cracking unit, 528
- Molecular complex formation
  - adduct
    - composition, 232–233
    - properties, 234–235
    - structure, 233–234
  - fractional composition of petroleum, 231–235
  - thiourea adduction, 232
  - urea adduction, 231–232
- Molecular sieve process
  - for acid gas removal, 728
- Molybdena-alumina ( $\text{MoO}_2\text{-Al}_2\text{O}_3$ ) catalyst, 682
- Molybdenum, 591
- Molybdenum sulfide ( $\text{MoS}_2$ ), 629
- Monoethanolamine (MEA), 715, 725
- Monolayer compression studies, 359

- Motor octane number (MON), 662  
 Motor oil, *See* Crankcase oil  
 Moving-bed processes, 525, 667  
   catalytic cracking  
     airlift thermofor catalytic cracking, 529  
     houdresid catalytic cracking, 529  
     houdriflow catalytic cracking, 529  
     socony airlift TCC process, 529  
     suspensoid catalytic cracking, 529–530  
   catalytic reforming, 672  
   hyperforming, 672  
   thermoform catalytic reforming, 672  
 Moving-beds, 521  
 MRH process, 622–623  
 Multitechnique approach, classification of  
   petroleum by, 42–43  
*Mycobacterium goodii*, 594
- N**
- Nafta, *See* Naphtha  
 Nalfining process, 693  
 Naphtha, 3, 8–9, 395; *see also* Solvents (naphtha)  
   cracking, 515  
   fractions, 751  
   production, 783  
 Naphthenes, 15, 35–36, 822  
 National Pollution Discharge Elimination System  
   (NPDES) permit, 856  
 Native asphalt, *see* Bitumen  
 Native/natural materials  
   asphaltite, 14, 18  
   asphaltoid, 14, 18–19  
   bitumen, 14, 16–17  
   bituminous rock and bituminous sand, 19  
   coal, 14  
   heavy oil, 14, 16  
   kerogen, 14, 19–20  
   natural gas, 14, 20–21  
   ozocerite, 14  
   petroleum, 14–16  
   wax, 17–18  
 Natural gas, 3, 14, 20–21, 74–76, 99, 642–643,  
   653, 659, 827  
   constituents, 20, 708  
   diluent or contaminants, 75  
   flow from well to consumer, 707–708  
   nonhydrocarbon constituents, 75  
   petrochemicals from, 799–801  
   transportation, 138–139  
 Natural gas liquids (NGL), 707, 724–725  
 Natural gasoline, 76  
 Natural wax, *see* Ozocerite  
 Nickel, 406, 530, 591  
 Nickel-molybdenum (Ni-Mo) catalysts, 591,  
   593, 634  
 Nickel oxide-silica-alumina catalyst, 573  
 Nickel sulfide (NiS), 629  
 Nickel-tungsten (Ni-W) catalysts, 591, 593  
 Nicotine, 766  
 Nitric acid oxidation, Kerogen, 91  
 Nitrogen, 406  
 Nitrogen (N<sub>2</sub>) gas, 531  
 Nitrogen oxides (NO<sub>x</sub>), 531, 647  
 Nitrogen removal, gas processing, 724  
*Nocardia* sp., 594  
 Nonassociated natural gas, 75, 707  
 Nondestructive hydrogenation, 415  
 Nonmining methods  
   cold heavy oil production with sand technology,  
     163, 167–169  
   cold production, 163  
   combustion processes, 160–163  
   gravity-driven processes, 163  
   heavy oil and bitumen, 157–173  
   horizontal well technology, 163–164  
   inert gas injection, 163–165, 169  
   microbial enhanced oil recovery processes,  
     169–173  
   pressure pulse flow enhancement technology,  
     163, 168–169  
   steam-assisted gravity drainage, 163, 165–167  
   steam-based processes, 159–160  
   vaporassisted petroleum extraction, 163,  
     168–169  
 Nonvolatile fractions, 349–350  
   composition, 349  
   molecular weight, 350  
   structure, 349–350
- O**
- Occupational Safety and Health Act, 814–815  
 Occupational Safety and Health Administration  
   (OSHA), 814  
 Occurrence, 69–79  
   bitumen, 76–79  
   conventional petroleum, 70–74  
   heavy oil, 76  
   natural gas, 74–76  
   reserves, 70–73  
 Ocean drilling, 113  
 Octane numbers, 411, 662–663  
   gasoline, 740–741, 746–748  
   reformate yield, 666, 668  
 Oil(s), 14, 25  
   fraction, 315, 319  
   future prospects, 28

- mining, 150–157
    - cold-water process, 155
    - draglines and bucket-wheel reclaimers, 152
    - enhanced oil recovery method, 156
    - hot-water process, 152–155
    - reservoir properties affecting efficiency, 151
    - sand-reduction process, 155
    - solvent extraction process, 155–156
    - surface mining, 151–152
    - tar sand mining, 150–152
    - truck and shovel method, 152
  - permeability, effect on, 143, 146
  - prices, 26–28
    - history, 27–28
    - strategies, 27
  - recovery, *see* Recovery of oils
  - sand, 17, 66, 76–77
    - resource, liquid fuels production from, 138
  - shale, 19
  - viscosity effect on, 143, 145
  - Oil-in-water dispersion (OWD) dynamics, 855
  - Oil Pollution Act of 1990, 814–815
  - Olefins
    - chemicals from, 793–799
      - halogenation, 796
      - hydroxylation, 794–795
      - oxidation, 797
      - polymerization, 796
    - polymerization, 425, 796
  - Once-through partial conversion (OTPC),
    - concept, 608–609
  - Organic compounds, flammability limits of,
    - 740–741
  - Organic facies, 58
  - Organic matter
    - deposition of, 52
    - transformation into petroleum, 57–58
  - Organic sediments, subdivision of, 33–34
  - Organic sulfur compounds, nomenclature and
    - types, 686
  - Orthoflow fluid-bed catalytic cracking, 528
  - Oxidation inhibitors, 748
  - Oxidative processes
    - bender, 696
    - copper sweetening, 696–697
    - doctor, 697
    - hypochlorite sweetening, 697
    - inhibitor sweetening, 698
    - merox, 698
    - product treating, 696–698
  - Oxygen, 406
  - Oxygenated gasoline, 749, 868
  - Oxygenates, 748–749
  - Oxygen (O<sub>2</sub>) gas, 531
  - Ozocerite, 14, 17–18
  - Ozokerite, *see* Ozocerite
- P**
- Packed column absorption systems, 714
  - Palladium sulfide (PdS), 629
  - Paraffin-base crude oil, 466
  - Paraffin compounds, 822
  - Paraffin oil, *see* Kerosene
  - Paraffins, 35–36
    - chemicals from, 789–793
      - alkylation, 792
      - halogenation, 789–790
      - oxidation, 791–792
      - thermolysis, 793
    - wax, 8, 11, 758, 769–771
  - Paraffins, iso-paraffins, naphthenes, and
    - aromatics (PINA) analysis of
      - petroleum, 229
  - Paraffins, iso-paraffins, olefins, naphthenes,
    - and aromatics (PIONA) analysis of
      - petroleum, 229
  - Paraffins, naphthenes, and aromatics (PNA)
    - analysis of petroleum, 229
  - Paraffins, olefins, naphthenes, and
    - aromatics (PONA) analysis
      - of petroleum, 229
  - Partial oxidation process, hydrogen production,
    - 649, 652–653
  - PD tar, *see* Propane deasphalter asphalt
  - Penex process, isomerization, 676
  - Pentafining process, isomerization, 677
  - Pentane-hexane isomerization, 675
  - Percolation filtration process, 695
  - Petrochemical industry, hydrocarbon
    - intermediates used in, 433–434
  - Petrochemicals; *see also* Petroleum
    - from acetylene, 799
      - aliphatic compounds, 787
      - aromatic compounds, 787
      - from aromatics, 797–799
      - hydrocarbon intermediates, 433–434
      - inorganic petrochemicals, 787, 801–802
      - intermediates and derivatives, 433–434, 783–784
      - from natural gas, 799–801
      - from olefins, 793–799
        - halogenation, 796
        - hydroxylation, 794–795
        - oxidation, 797
        - polymerization, 796
      - from paraffins, 789–793
        - alkylation, 792
        - halogenation, 789–790

- nitration, 790–791
- oxidation, 791–792
- thermolysis, 793
- primary petrochemicals, 783–784
- products and uses, 785–786
- refining processes, 433–434
- synthesis gas, 787, 802–803
- types, 787
- Petrolatum, 22, 565, 705, 763
- Petrolenes, 25, 319
- Petroleum; *see also* Petrochemicals
  - carbon-based resource, 3
  - changes effecting balance, 365
  - chemical and physical structure, 350–355
  - chemical component, 179–181
    - hydrocarbon constituents, 181–187
    - nonhydrocarbon constituents, 187–195
  - chemical factors in, fractional composition of, 222–223
  - classification by
    - API gravity, 37–38, 40
    - boiling point, 42
    - carbon distribution, 39
    - chemical composition, 34–36
    - chromatographic data, 42
    - correlation index, 36–37
    - density (specific gravity), 37–38
    - hydrocarbon resource, 33–34
    - multitechnique approach, 42–43
    - pour point, 41
    - recovery method, 40–41
    - reservoir characterization, 43–45
    - systems, 31–45
    - UOP characterization or classification factor, 40
    - viscosity, 38–40
    - viscosity-gravity constant, 39–40
  - components, 15, 179–181
  - composition, 67–69
  - definitions and terminology, 12–14, 31
  - derivatives, 3–5
    - references in Bible, 4–5
  - development stages, 51
  - deviated well drilling, 45
  - distillation, 9, 181, 195–201
  - energy source, 47–48
  - formation from kerogen, 84–85
  - fractional composition, 205–237
    - adsorption, 222–229
    - chemical methods, 229–235
    - distillation, 207–214
    - solvent treatment, 214–222
    - studies, 235–236
  - fractionation, 25
    - scheme for, 206
  - fractions, environmental analysis, 877
  - fuels derived from, 3
  - genesis, 50–51
  - group analysis
    - gas chromatography, 874–875
    - gas chromatography-mass spectrometry, 876–877
    - high-performance liquid chromatography, 875–876
    - immunoassay, 873–874
    - refineries, 872–877
    - thin layer chromatography, 873
  - heteroatom types in, 181
    - by distillation, 195–201
  - historical perspectives, 3–10
  - hydrocarbon constituents, 15, 35, 822
  - jelly, 565, 705, 769
  - kerogen role in maturation process, 85
  - maturation process, 69
  - migration mechanisms, 60–61
  - modern perspectives, 10–12
  - molecular species, 32, 346–350
  - as native material, 14–16
  - nitrogen compounds, 223
  - nonhydrocarbon constituents, 15
  - occurrence, 69–79
    - bitumen, 76–79
    - conventional petroleum, 70–74
    - heavy oil, 76
    - natural gas, 74–76
    - reserves, 70–73
  - origin
    - abiogenic, 48–50, 66–67
    - abiogenic theory of, 85
    - biogenic, 50–67
    - biogenic theory of, 83
  - oxygen compounds, 223
  - paraffins, iso-paraffins, naphthenes, and aromatics (PINA) analysis, 229
  - paraffins, iso-paraffins, olefins, naphthenes, and aromatics (PIONA) analysis, 229
  - paraffins, naphthenes, and aromatics (PNA) analysis, 229
  - paraffins, olefins, naphthenes, and aromatics (PONA) analysis, 229
  - and petroleum products, 734; *see also* Product improvement; Products; Product treating
  - assessment of analysis methods, 877–880
  - environmental analysis, 862–864
  - gas chromatographic methods, 866–869
  - gravimetric methods, 870–871
  - immunoassay methods, 871
  - infrared spectroscopy methods, 869–870

- leachability, 864
- properties, 736
- refining processes, 431–432
- total petroleum hydrocarbons (TPH), 864–871
- toxicity, 864
- uses, 3
- process development since modern refining era, 10
- properties, 14, 67–69
- recovery, 364–370
  - effect of reservoir heterogeneity, 99–100
- refinery, 465–466; *see also* Refinery layout, 828
- reservoir, identification and quantification, 43–45
- spirit, 9
- structure, 345–370
  - chemical and physical, 350–355
  - instability of crude oil system and, 355–64
  - molecular species, 346–350
  - recovery and refining effects, 364–370
  - stability of crude oil system and, 355–64
- subdivision of, 14
- sulfur compounds, 223
- technology, related words linguistic origins, 4–8
- thermal reaction, 364
- in situ* transformation, 63–66
  - biodegradation and water washing, 66
  - deasphalting, 65–66
  - thermal alteration, 63–65
- trap, 60
- ultimate elemental composition, 178–179
- uses, 661
  - in historical perspective, 733–734
- water-soluble fraction, 854
- wax, 769
- Petroleum, structure of**
  - chemical and physical, 350–355
  - instability of crude oil system and, 355–364
  - molecular species, 346–350
  - nonvolatile fractions, 349–350
  - resin constituents, 347–349
  - volatile fractions, 346
  - recovery and refining effects, 364–370
  - refining operations effects, 368–370
  - stability of crude oil system and, 355–64
- Petroleum exploration, 99–106**
  - borehole logging methods, 105–106
    - acoustic, 105
    - density, 105
    - electrical, 105
    - radioactive, 105
  - drilling operation, 106–110
    - electrical methods, 104
    - electromagnetic methods, 104–105
    - gravity methods, 101–102
    - magnetic methods, 102–103
    - radioactive methods, 105
    - seismic methods, 103
    - subsurface exploration, 101
    - well completion, 110–111
- Petroleum industry, environmental aspects**
  - definitions, 809–811
  - process analysis, 815–824
    - gaseous emissions, 818–822
    - liquid emissions, 822–823
    - solid emissions, 823–824
  - refining, 807–824
  - regulations, 811–815
- Phenol treatment process, 701**
- Phosphate desulfurization process, for acid gas removal, 727**
- Phosphates catalyst, 683**
- Photosynthesis, 52**
- Phytobacteria, 52**
- Phytoplankton, 52**
- Pipestill furnaces, 470**
- Pipestill gas, 708**
- Pipestill light ends, 708, 816**
- Pitch, 4–7, 14, 23–24**
  - lake, 24
- Plate column absorption systems, 714**
- Platforming processes, 645–646, 669–671, 709, 782**
- Platinum-alumina catalyst, 573**
- Platinum catalyst, 645, 675, 682**
- Polar-aromatics, 345–346**
- Polar solvents, 221**
- Pollutant, 809**
- Polyforming, 665**
- Polymer**
  - augmented waterflooding, *see* Polymer, flooding
  - degradation in service, recovery of oil, 124
  - flooding, 121–123, 134
  - gasoline, 447, 521, 680
- Polymerization processes, 51, 58, 446–447, 488, 521, 569, 665**
  - bulk acid polymerization, 681–682
  - catalysts, 425, 683–684
  - historical development, 424
  - modern development, 424–425
  - product improvement, 680–682
  - refining processes, 424–425
  - solid phosphoric acid condensation, 681
  - thermal polymerization, 680–681
- Polysulfide treatment process, 690**
- Porphyrins, 56–57, 223**

- Possible reserves, 70
- Potential reserves, 70
- Pour point, classification petroleum by, 41
- Powerforming processes, 645, 671
- PPT, *see* Pressure pulsing technologies
- Precipitation method, *see* Deasphalting processes
- Pressure pulse flow enhancement technology, 163, 168–169
- Pressure pulsing technologies (PPT), 163, 168
- Pressure-swing adsorption (PSA) units, hydrogen purification, 656–657
- Pressure-swing distillation, 481
- Pretreatment for distillation, 467–468
- Primary oil recovery, 99, 114–117
- Primary petrochemicals, 783–784
- Primary recovery, 143
  - of oil, 99, 114–117
- Probable reserves, 70
- Process chemistry, 447–461
  - hydroconversion chemistry, 456–457
  - in refinery, 457–462
    - hydroprocessing, 460–462
    - visbreaking, 457–460
  - thermal chemistry, 447–456
- Process gas, 708–709, 781, 818
- Process parameters
  - additives, 544
  - catalyst life, 578–579
  - catalyst variables, 542–543
  - for catalytic cracking, 538–544
  - coking, 540–542
  - feedstock effects, 579–581
  - hydrodesulfurization, 577, 579
  - hydrogen partial pressure, 578
  - hydrotreating and desulfurization, 576–581
  - process variables, 543–544
  - reaction temperature, 578
  - reactor, 539–540
  - recovery of oil, 111
  - space velocity, 578
- Process wastewater, 831
- Product improvement, 661–683; *see also* Products;
  - Product treating
    - alkylation, 677–679
      - cascade sulfuric acid, 678
      - hydrogen fluoride, 679
    - catalysts, 682–684
      - alkylation processes, 683
      - isomerization processes, 683
      - polymerization processes, 683–684
      - reforming processes, 682–683
    - catalytic reforming, 665–673
      - fixed-bed processes, 668–672
      - fluid-bed processes, 672–673
      - moving-bed processes, 672
    - isomerization, 673–677
      - butamer process, 675
      - butomerate process, 675–676
      - hysomer process, 676
      - Iso-Ke process, 676
      - isomate process, 676
      - isomerate process, 676
      - penex process, 676
      - pentafining process, 677
- Products, 733–778; *see also* Product improvement;
  - Product treatment processes
    - acid sludge, 777
    - asphalt, 733–735, 737, 771–775
      - composition, 771–772
      - manufacture, 772–774
      - properties and uses, 774–775
    - blending, 777–778
    - coke, 735, 774, 776
    - fuel oil, 736, 756–758
    - gaseous fuels, 733, 738–742
      - composition, 738–739
      - manufacture, 739
      - properties and uses, 739–742
    - gasoline
      - additives, 748–750
      - composition, 742–743
      - manufacture, 743–746
      - octane numbers, 746–748
      - properties and uses, 746
    - grease, 766–768
      - aluminum soap, 768
      - cold sett grease soap, 768
      - lime soap, 766–768
      - lithium and barium soap, 768
      - soda soap, 768
  - historical perspective, 733–738
  - insecticides, 766
  - insulating oil, 765–766
  - kerosene, 736–738, 754–756
    - composition, 755
    - manufacture, 755–756
    - properties and uses, 756
  - lubricating oil, 733, 758–764
    - composition, 759
    - manufacture, 759–764
    - properties and uses, 763–764



- and product quality
    - recovery of oil, 133–134
  - solvents (naphtha), 738, 750–754, 783
    - composition, 750
    - manufacture, 751–752, 783
    - properties and uses, 753–754
  - sulfonic acids, 776–777
  - wax, 737, 769–771
    - composition, 769
    - manufacture, 769–771
    - properties and uses, 771
  - white oil, 764–765
  - Product treatment processes, 685–706;
    - see also* Product improvement;
    - Products
  - acid processes, 691–694
    - nalfining, 693
    - sulfuric acid treatment, 693–694
  - caustic processes, 688–691
    - Dualayer distillate, 689
    - Dualayer gasoline, 689
    - electrolytic mercaptan, 689
    - ferrocyanide, 689
    - lye treatment, 689–690
    - mercapsol, 690
    - polysulfide treatment, 690
    - sodasol, 690–691
    - solutizer, 691
    - steam regenerative caustic
      - treatment, 691
    - unisol, 691
  - clay processes, 694–696
    - alkylation effluent treatment, 694
    - arosorb, 694
    - bauxite treatment, 694–695
    - continuous contact filtration, 695
    - cyclic adsorption, 695
    - gray clay treatment, 695
    - percolation filtration, 695
    - thermoform continuous percolation,
      - 695–696
  - historical aspects, 685–688
  - oxidative processes, 696–698
    - bender, 696
    - copper sweetening, 696–697
    - doctor, 697
    - hypochlorite sweetening, 697
    - inhibitor sweetening, 698
    - merox, 698
  - processes, 688–706
  - solvent processes, 698–706
    - deasphalting, 699–700
    - dewaxing, 703–706
    - solvent refining, 700–703
  - Propane
    - asphalt, 319
    - deasphalting, 699, 848
    - decarbonizing, 509, 700
    - dewaxing process, 564, 704, 761
    - fractionation, 700
    - properties, 738
  - Propane deasphalter asphalt (PDA), 547
  - Propylene, chemicals from, 789
  - Prospective resources, 71
  - Proteins, 55
  - Protopetroleum, 51, 54, 94, 178, 321
  - Proved reserves, 71
  - PSA units, *see* Pressure-swing
    - adsorption units
  - Publicly owned treatment works
    - (POTW), 856
  - Pyrethrum, 766
  - Pyrobitumen, 18–19; *see also* Asphaltoids
  - Pyrolysis processes, 601
    - hydrogen production, 648–649
- ## Q
- Quicklime (CaO), 9
- ## R
- Radioactive methods, exploration for
    - petroleum, 105
  - Rate of solution, 214
  - RCD unibon (BOC) process, hydrocracking, 623
  - Reactive distillation, 481, 485
  - Reactors, 539–540
    - demetallization, 583
    - downflow fixed-bed, 576, 581–582
    - guard bed, 583
    - hydrotreating and desulfurization, 576, 581–583
    - upflow expanded-bed, 582
  - Recovery method, petroleum classification by,
    - 40–41
  - Recovery of heavy oil and bitumen, 143–173;
    - see also* Recovery of oils
    - in situ* combustion, 143
    - enhanced oil recovery (EOR) methods, 143, 146
    - in situ* extraction processes, 149
    - oil permeability effect on, 143, 146
    - oil viscosity effect on, 143, 145
    - primary recovery, 143
    - reservoir depth effect on, 143, 145
    - secondary recovery, 143
    - site specific and other variable factors,
      - 143–144
    - subdivision of recovery methods, 143–144

- THAI process, 148–149
- thermal enhanced oil recovery processes, 148
- thermal methods, 143, 147–148
- Recovery of oils, 99, 111–133; *see also*
  - Recovery of heavy oil and bitumen
  - adverse effects of process parameters, 111
  - applicability of recovery methods, 120
  - combination of forward combustion and waterflood (COFCAW) process, 133, 162–163
  - in situ* combustion, 132–134
  - enhanced oil recovery, 99, 119–133
  - polymer degradation in service, 124
  - primary recovery, 99, 114–117
  - process parameters, 111
  - products and product quality, 133–134
  - secondary recovery, 99, 117–119
  - sludge and sediment formation, 111
  - thermal methods, 129
  - water driven mechanism, 116
- Recycle stock, 439
- Reduced crude, 210
- Reduced crude oil conversion (RCC) process,
  - heavy feedstocks, 533–535
- Reduced pressure distillation, fractional
  - composition of petroleum, 211–213
- Refineries, 465–466
  - biodegradation processes, 862
  - chemical industry feedstocks, 827
  - environmental analysis, 861–880
    - assessment of methods, 877–880
    - leachability, 864
    - petroleum fractions, 877
    - total petroleum hydrocarbons (TPH), 864–871
    - toxicity, 864
  - equipment and facilities at, 465–466
  - finished nonfuel products, 827
  - hydroprocessing, 460–462
  - layout, 828
  - monitoring program, 861
  - outlook to wastes, 858–859
    - hazardous waste regulations, 858
    - regulatory background, 858
    - requirements, 858–859
  - petroleum group analysis, 872–877
    - gas chromatography, 874–875
    - gas chromatography-mass spectrometry, 876–877
    - high-performance liquid chromatography, 875–876
    - immunoassay, 873–874
    - thin layer chromatography, 873
  - process chemistry, 457–462
    - products, 827
    - regulatory requirements, 861
    - releases to air from
      - bulk storage operations, 861
      - combustion plants, 861
      - refining operations, 861
      - volatile organic compounds, 861
    - schematic overview, 396, 809
    - soil and groundwater contamination, 861
    - total petroleum hydrocarbons (TPH)
      - gas chromatographic methods, 866–869
      - gravimetric methods, 870–871
      - immunoassay methods, 871
    - upgrade pollution abatement equipment, 861
    - visbreaking, 457–460
    - wastes form
      - alkylation, 843–845
      - catalytic reforming, 842–843
      - coking, 836–837
      - deasphalting, 847–848
      - desalting, 831–832
      - dewaxing, 848–849
      - distillation, 832–835
      - fluid catalytic cracking, 838–839
      - gas processing, 849–850
      - hydrocracking, 839–842
      - hydrotreating, 839–842
      - isomerization, 845–846
      - polymerization, 846–847
      - process emissions and waste, 829–830
      - thermal cracking, 835–836
      - visbreaking, 835–836
    - wastes management, 859–860
    - wastes toxicity, 857–858
    - wastes types, 850–857
      - gases, 852–854
      - higher boiling constituents, 854–855
      - lower boiling constituents, 852–854
      - solid waste, 857
      - wastewater, 855–856
    - weathering processes, 861–862
- Refinery gas, 642–643, 659, 708, 781, 818
- Refinery processes
  - conversion, 397, 438–439
  - conversion to liquids for, 572
  - finishing, 438
  - process conditions, 571
  - reforming, 438
  - separation, 438
- Refining chemistry, 437–462; *see also*
  - Refining processes
    - alkylation, 446
    - cracking, 439–443
    - catalytic, 440–442

- dehydrocyclization, 443
- dehydrogenation, 443
- thermal, 439–440
- environmental aspects, 807–824
- environmental regulations, 811–815
- hydrogenation, 443–445
- hydrocracking, 444
- hydrotreating, 444–445
- isomerization, 445–446
- polymerization, 446–447
- process analysis, 815–824
- process chemistry, 447–461
- hydroconversion, 456–457
- hydroprocessing, 460–462
- in refinery, 457–462
- thermal, 447–456
- visbreaking, 457–460
- Refining processes; *see also* Refining chemistry
  - alkylation processes, 423–424
  - catalysts, 414–415, 424
  - catalytic methods, 411–415
  - catalysts, 414–415, 424
  - historical development, 411–413
  - modern development, 413–414
  - concepts and configurations for heavy feedstocks, 430
  - conversion processes, 397, 438–439
  - desalting, 398–399
  - dewatering and desalting, 398–399
  - distillation, 400–405
  - atmospheric, 402–403
  - azeotropic and extractive, 405
  - historical development, 401–402
  - modern development, 396, 402–405
  - vacuum, 396, 403–405
  - early, 399–400
  - finishing, 397
  - historical development, 401–402, 405–407, 411–416, 418, 421–424
  - hydroprocesses, 415–418
  - historical development, 415–416
  - hydrofining, 418
  - modern development, 415–418
  - isomerization, 421–423
  - catalysts, 422–423
  - historical development, 421–422
  - modern development, 421–422
  - modern development, 396, 402–405, 408–411, 413–417, 419–425
  - petrochemicals, 433–434
  - petroleum products, 431–432
  - polymerization processes, 424–425
  - catalysts, 425
  - historical development, 424
  - modern development, 424–425
  - refining heavy feedstocks, 396, 427–431
  - reforming, 418–421
  - catalysts, 420–421
  - catalytic reforming, 419–420
  - historical development, 418
  - modern development, 419–421
  - thermal reforming, 419
  - separation processes, 397
  - solvent processes, 425–427
  - deasphalting, 425–426
  - dewaxing, 426–427
  - thermal methods, 405–412
  - coking, 409–712
  - historical development, 405–407
  - modern development, 408–411
  - thermal cracking, 408
  - visbreaking, 408–409
- Reformate, 665
- Reforming catalysts, 420–421, 653–654, 682–683
- Reforming processes, 438, 569, 662, 709, 781–782, 819
- catalysts for, 420–421, 653–654, 682–683
- catalytic, 419–420
- historical development, 418
- modern development, 419–421
- product improvement, 662–673
- refining, 418–421
- thermal, 419
- Refrigeration compressor oils, 692
- Renewable energy sources, 808
- Repressurizing oil well, 112
- Rerunning process, 399, 479
- Research octane number (RON), 662
- Reserves, 70–73
- Reservoir(s)
  - characterization, classification petroleum by, 43–45
  - depth effect on, 143, 145
  - properties affecting efficiency, 151
  - sediments, accumulation in, 58–63
- Residfining process
  - hydrocracking, 623
  - hydrotreating and desulfurization, 589–590
- Resid hydrocracking process, 10
- Residual fuel oils, 489, 756–757, 863
- Residue fluid catalytic cracking (HOC) process, heavy feedstocks, 531–532
- Residue hydroconversion (RHC) process, hydrocracking, 624
- Residuum, 14, 22, 466, 473–475
- properties of, 473

- Residuum desulfurization process,  
 hydrotreating and desulfurization,  
 473, 588–589
- Residuum fluidized catalytic cracking (RFCC),  
 530–531
- Residuum oil supercritical extraction process,  
 560–561
- Resins, 4, 315, 319, 347–349  
 composition, 347  
 fraction, crude oil, 205  
 molecular weight, 349  
 and oils, 14, 25  
 oxidation, 348, 351  
 structure, 347–349
- Resource Conservation and Recovery Act  
 (RCRA), 813, 815, 858–859
- Rexforming process, 671
- Rhodococcus erythropolis*, 594
- Rich oil, 723
- Riser reactor, 528
- Road oils, 774
- Rock asphalt, 16
- ROSE process, 548
- Rosin oil, 768
- Rotenone, 766
- R2R process, heavy feedstocks, 533–534
- S**
- Saddle point, 482
- Safe Drinking Water Act, 812, 815
- SAGD, *see* Steam-assisted gravity drainage
- Sand-reduction process, 155
- Sandstone, 15
- SAPA method, *see* Saturates-aromatics-  
 polars-asphaltenes method
- Sapropel, 19
- SARA method, *see* Saturates-aromatics-  
 resins-asphaltenes method
- Saturates, 14, 25, 315, 345–346
- Saturates-aromatics-polars-asphaltenes (SAPA)  
 method, fractional composition of  
 petroleum, 225
- Saturates-aromatics-resins-asphaltenes (SARA)  
 method, fractional composition of  
 petroleum, 225–226
- Saturates fraction, 222  
 crude oil, 205
- SCANfining, 586
- Schmidt vertical magnetometer, 102
- SCOT process, 852–853
- Secondary oil recovery, 99, 117–119, 143
- Sediment formation, 350, 360, 365, 369, 450,  
 454–456
- steric colloidal model, 361–362
- Seismic methods, exploration for  
 petroleum, 103
- Selective cracking, 515
- Selectoforming process, 671–672
- Semi-permeable membrane device  
 (SPMD), 855
- Separation processes, 430, 438  
 refining processes, 397
- Separator-Nobel dewaxing, 564, 704
- Sepiolites, 530
- Shell Claus off-gas treating (SCOT) process, 730
- Shell FCC process, heavy feedstocks, 534–536
- Shell gasification process, hydrogen  
 production, 649
- Shell soaker visbreaking process, 497–498
- Shell still, 479
- Shell thermal cracking, 515–517
- Shell two-stage fluid-bed catalytic cracking, 528
- Shift conversion catalysts, 654–655
- Short-path distillation, 209
- Sieve trays, 477
- Silica-alumina ( $\text{SiO}_2\text{-Al}_2\text{O}_3$ ) catalyst, 537, 682, 686
- Silica-magnesia catalysts, 537
- Siltstone, 15
- Single-stage and two-stage options,  
 hydrocracking, 603, 606–610
- Single-stage once-through (SSOT) unit, 608
- Single-stage recycle (SSREC) unit, 608
- Site specific and other variable factors, 143–144
- Slack wax, 704, 762
- Slime (bitumen), 4–7
- Sludge, 356, 760  
 formation, 454–456  
 and sediment formation, recovery of oil, 111
- Soaker visbreaking, 495–496
- Society for Petroleum Engineers, 71
- Socony airlift TCC process, 529
- Soda soap, 768
- Sodasol process, 690–691
- Sodium carbonate process, 688
- Solid emissions environment aspect, 823–824
- Solid phosphoric acid condensation, 681
- Solubility parameter, 218, 236, 454–455  
 asphaltenes, 454
- Soluble oil, 122
- Solutizer process, 691
- Solvahl deasphalting process, 561–562
- Solvent naphtha, 827
- Solvent processes  
 deasphalting, 425–426, 547, 698–700  
 dewaxing, 10, 426–427, 562–565,  
 703–706, 761  
 mechanism, 703

- extraction, 10, 155–156
  - furfural use in, 702
  - hydrogen fluoride use in, 702
  - liquid sulfur dioxide use in, 701–702
  - phenol use in, 701
  - product treating, 698–706
  - refining, 425–427, 700–703, 760–761
  - sulfolane use in, 703
  - Udex extraction, 702
  - Solvents (naphtha), 738, 750–754, 783
    - composition, 750
    - manufacture, 751–752, 783
    - properties and uses, 753–754
  - Solvent treatment
    - fractional composition of petroleum, 214–222
      - asphaltene separation, 216–220
      - fractionation, 220–222
  - Soot-free synthesis gas, 652
  - Sorption-enhanced methane, 650
  - Source beds, 52–54, 61
  - Sour natural gas sweetening, 725
  - Spent lye, 690
  - Spindle oil, 475
  - Stabilization and light end removal,
    - in distillation, 479–480
  - Stable nodes, 482
  - Stack gas, 848
  - Steam
    - flooding, 130–131, 134
    - injection, 130–131; *see also* Steam drive injection (steam injection)
    - regenerative caustic treatment process, 691
    - soak, 130
    - stimulation, 158
  - Steam-assisted gravity drainage (SAGD), 163, 165–167, 169
  - Steam-based processes, 159–160
  - Steam drive injection (steam injection), 130–131, 159
  - Steam-methane reforming, hydrogen production, 649–651, 654
  - Steam-naphtha reforming, hydrogen production, 651
  - Steric, colloidal model, 361–362
  - Sterols, 55
  - Stoddard solvent, 750, 863
  - Stove oil, 757
  - Straightrun gas oil, 522
  - Straight-run gasoline, 76
  - Stripping operation, 470–471
    - in distillation, 478–479
  - Subdivision of recovery methods, 143–144
  - Subsea satellite platforms, 113
  - Subsurface exploration, exploration for petroleum, 101
  - Sucker-rod pump, *see* Horsehead pump
  - Sulfonic acids, 776–777
  - Sulfur, 406
  - Sulfur-free diesel fuel, 597
  - Sulfuric acid
    - alkylation process, 679, 845
    - as catalyst, 683
    - desulfurization, 687–688
    - treatment process, 693–694
  - Sulfur oxides (SO<sub>x</sub>) gas, 531
  - Superfractionation, 480–481
  - Superfund Amendments and Reauthorization Act (SARA), 812, 814–815, 858
  - Surface mining, 151–152
  - Surfactant flooding, 121–122, 125
  - Suspensoid catalytic cracking, 529–530
  - Sweated waxes, 770
  - Sweating process, 762
  - Sweep efficiency, 118
  - Sweetening gas, 724–725
  - Sweetening natural gas, 849
  - Sweetening processes, 10, 595–596, 685, 688, 696–698, 711, 820
  - S&W FCC process, *see* S&W fluid catalytic cracking process
  - S&W fluid catalytic cracking process, heavy feedstocks, 536–537
  - Syncrude, 24, 149
  - Synthesis gas, 787, 802–803
    - hydrogen production, 651–652
  - Synthetic crude oil, 14, 24, 149
- ## T
- Tannin solutizer process, 691
  - Tar, 14, 23–24, 490
  - Tar sand bitumen, 16–17, 77–78, 143
    - processing sequence for, 431
    - product yields and properties from delayed coking, 501
    - visbreaking, 497
  - Tar sand mining, 150–152
  - TCC, *see* Thermofor catalytic cracking
  - Tertiary-amyl methyl ether (TAME)
    - oxygenate, 749
  - Tertiary oil recovery, *see* Enhanced oil recovery
  - Tervahl-H process
    - hydrocracking, 624
  - Tervahl-T process, 517–518
  - Tetraethyl lead (ethyl fluid), 521
  - Texaco gasification process

- hydrogen production, 652–653
  - THAI process, *see* Toe-to-heel air injection process
  - Thermal (carbon rejection) processes, 574, 602
  - Thermal chemistry, 447–456
  - Thermal coke, 448–449
  - Thermal cracking processes, 10, 406, 408, 439–440, 487–518, 709, 781, 784, 817
    - coking, 499–506
    - commercial processes, 493–518
    - early processes, 492–493
    - options for heavy feedstocks, 507–518
    - visbreaking, 494–499
  - Thermal decomposition, 469
  - Thermal enhanced oil recovery processes, 148
  - Thermal methods, 143, 147–148
    - coke yield production in, 491
    - coking, 409–412
    - cracking, 408
    - historical development, 405–407
    - modern development, 408–411
    - recovery of oil, 129
    - refining processes, 405–411
  - Thermal oxidation, 713
  - Thermal polymerization, 424, 680–681
  - Thermal reforming process, 10, 419, 488, 521
    - product improvement, 664–665
  - Thermostat catalytic cracking (TCC), airlift, 529
  - Thermostat catalytic reforming (TCR), 645, 672
  - Thermostat continuous percolation process, 695–696
  - Thin layer chromatography (TLC), 872–873
  - Thiocyanates, 766
  - Thiourea adduction, 232
  - Tia Juana crude oil, properties of, 42
  - Toe-to-heel air injection (THAI) process, 148–149
  - Toluene, chemicals from, 797–798
  - Topping refinery, 397
  - Total petroleum hydrocarbons (TPH)
    - assessment of methods, 877–880
    - gas chromatographic methods, 866–869
    - gasoline (TPH-G), 865
    - gravimetric methods, 870–871
    - immunoassay methods, 871
    - petroleum and petroleum products, 864–871
  - Total petroleum-initially-in-place, 71
  - Total recoverable petroleum hydrocarbons (TRPH), 865, 879
  - Toxicity, petroleum and petroleum products, 857–858, 864
  - Toxic Substances Control Act, 813–815
  - Transformer oils, 765
  - Transportation of oil, 135–139
    - pipeline systems, 138–139
    - tankers for, 137
    - technological trends, 136
  - Trays, 477–478
    - classification, 477
    - downcomers, 478
    - efficiency, 478
    - parameter, 478
    - performance, 478
    - types, 477
  - Trichloroethylene dewaxing, 704
  - Triethanolamine (TEA), 715
  - Triethylene glycol (TEG), 720
  - Truck and shovel method, 152
  - Tube-and-tank cracking process, 406
  - Tungsten-nickel sulfide catalyst, 573
  - Tungsten sulfide (WS<sub>2</sub>), 629
  - Turpentine, 753
- U
- Udex extraction processes, 702, 752
  - Ultimate elemental analysis, kerogen, 89–90
  - Ultrafining process, hydrotreating and desulfurization, 587
  - Ultraforming processes, 645
  - Ultra-low-sulfur diesel (ULSD), 583, 626
  - Undiscovered petroleum-initially-in-place, 71–72
  - Undiscovered reserves, 70
  - Undiscovered resources, 70
  - Unicracking process, hydrocracking, 625–627
  - Unifining process, hydrotreating and desulfurization, 587
  - Unionfining process, hydrotreating and desulfurization, 587–588
  - Unisol process, 691
  - United States Bureau of Mines-American Petroleum Institute (USBM-API) method, fractional composition of petroleum, 225–226
  - Universal oil products (UOP)
    - catalytic dewaxing process, 566
    - characterization or classification factor, classification petroleum by, 40
    - fluid-bed catalytic cracking, 528–529
  - Unproved reserves, 72
  - Unstable nodes, 482
  - UOP, *see* Universal oil products
  - Upflow expanded-bed reactor, 582
  - Upgrading processes, conversion measures for, 604–605
  - Urea adduction, 231–232
  - Urea dewaxing, 564, 704–705
  - Used Oil Recycling Act of 1980, 858

## V

- Vacuum distillation, 10, 396, 403–405, 465, 468–470, 473–475, 547, 833–834
- Vacuum gas oils (VGO), 475, 522, 534, 603, 608, 610, 621–623, 626
- Vacuum residuum, 522
  - properties, 772
- Vacuum residuum desulfurization process, hydrotreating and desulfurization, 473, 588–589
- Valve trays, 477
- Vanadium, 406, 530
- Vanadium sulfide ( $V_2S_5$ ), 629
- Van Krevelen diagram, 86, 89
- VAPEX, *see* Vaporassisted petroleum extraction
- Vaporassisted petroleum extraction (VAPEX), 163, 168–169
- Vapor-phase cracking, 518
- Veba combi cracking (VCC) process, hydrocracking, 627–628
- Visbreaking processes, 10, 407, 451, 457–460, 494–499, 709, 817
  - with delayed coking and fluid coking, 495
  - refining processes, 408–409
- Visbreaking (viscosity breaking), 138
- Viscosity, classification of petroleum by, 38–40
- Viscosity-gravity constant
  - classification petroleum by, 39–40

## W

## Waste(s)

## forms

- alkylation, 843–845
- catalytic reforming, 842–843
- coking, 836–837
- deasphalting, 847–848
- desalting, 831–832
- dewaxing, 848–849
- distillation, 832–835
- fluid catalytic cracking, 838–839
- gas processing, 849–850
- hydrocracking, 839–842
- hydrotreating, 839–842
- isomerization, 845–846
- polymerization, 846–847
- process emissions and waste, 829–830
- thermal cracking, 835–836
- visbreaking, 835–836
- management, 859–860
- refinery outlook, 858–859
  - hazardous waste regulations, 858

- regulatory background, 858
- requirements, 858–859
- toxicity, 857–858, 864
- types, 850–857
  - gases, 852–854
  - higher boiling constituents, 854–855
  - lower boiling constituents, 852–854
  - solid waste, 857
  - wastewater, 855–856
- Wastewater treatment plants, 856
- Water cycle, 812
- Water driven mechanism, recovery of oil, 116
- Waterflood, 118, 121
- Water Pollution Control Act of 1948, 812, 815
- Water Quality Act of 1965, 812
- Water removal
  - absorption, 720
  - gas processing, 719–722
  - solid adsorbents, 720–721
  - use of membranes, 721–722
- Water-soluble fraction (WSF) of petroleum, 854
- Water washing and biodegradation, 66
- Wax, 14, 22, 737, 769–771, 827
  - composition, 769
  - hydrofining, 585–586
  - manufacture, 769–771
  - properties and uses, 771
  - separation, 455
- Weathered crude oil, 855
- Well completion
  - exploration for petroleum, 110–111
  - for petroleum exploration, 110–111
- Wellman-Land process, 853
- Wet casinghead gas, 119
- Wet gas, 21, 74
- Wet scrubbers, 718
  - hydrogen purification, 656–657
- White oils, 692, 764–765
- White spirit, 750
- World energy resources, distribution of, 26, 47–48
- Wurtzilite asphaltoids, 19

## X

- X-ray diffraction techniques, kerogen, 93
- Xylenes, chemicals from, 798–799

## Z

- Zeolites, 599–600, 630–633
  - catalysts, alkylation processes, 678
- Zinc oxide process, for acid gas
  - removal, 727