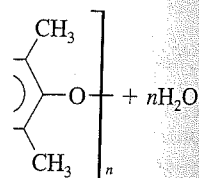


it is 354 K.
 $1/T$, the slope is
 l. **11.86** (a) There
) 30 double bonds.

a liquid crystal is
 rigid and has its
 id crystal is fluid.
 ryl benzoate has a
 diate between those
 uid-crystalline
 ansition tempera-
 rature is increased.
Nematic and *smetic*
 s aligned with their
 some additional or-
 ules are stacked in
 ct to molecules in
 a second sub-
 al intermolecular
 es present in the
 solute-liquid crys-
 rder, and very few
 fore the stability
 yed. **12.11** Poly-
 ar mass formed by
 ll molecules with

$\text{—CH=C—CH}_2\text{—}$
 $\quad \quad \quad \text{Cl}$
 $\quad \quad \quad \text{]}_n$
 molecules are com-
 ination of a small
 rmed when con-
 acting molecules



ases hardness;
 rdness; (e) de-
 ter is a polymer
 eased from a dis-
 er can be shaped
 /or pressure. (c)
 reshaped once set
 ls that crosslink
 ceramics are

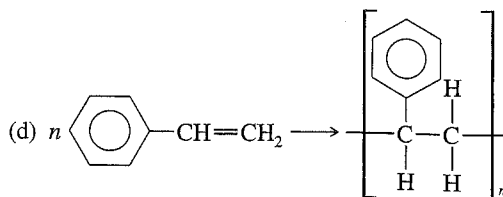
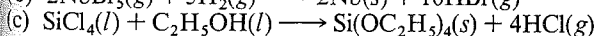
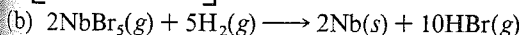
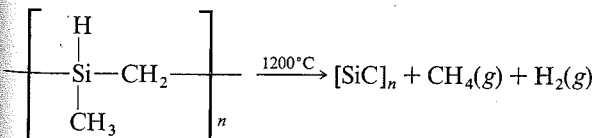
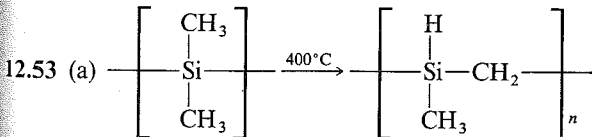
more resistant to heat than are plastics, are significantly
 less dense than metals, are resistant to corrosion and
 wear, and are not easily deformed by stress. **12.25** Each
 Si is bound to four C atoms, and each C is bound to four
 Si atoms in a tetrahedral arrangement, producing an ex-
 tended three-dimensional network. The extended three-
 dimensional nature of the structure produces the excep-
 tional hardness, and the covalent character of the
 bonding network provides the great thermal stability.

12.27 Ceramic materials typically have rigid three-di-
 mensional lattices; movements of atoms with respect to
 one another require the breaking of chemical bonds. As
 bonds in a ceramic are broken under stress, the break
 tends to propagate itself by applying stress to adjacent
 atoms and bonds. **12.29** If we begin with solid metal hy-
 droxide and add the appropriate solvents, we have little
 control over the particle size of the suspended solid or the
 uniformity of the sol. These characteristics of the sol are
 very important in determining the ultimate purity, partic-
 le size, and fracture resistance of the ceramic produced.

12.31 A *composite* is a material in which ceramic fibers
 have been embedded in a host ceramic matrix; the com-
 posite will be much more fracture-resistant than the pure
 host ceramic. **12.33** (a) Limited electrical conductivity
 that changes reproducibly with temperature; (b) hard-
 ness and fracture resistance due to fiber reinforcement;
 (c) structural stability and electrical insulation; (d) heat
 resistance and low density. **12.35** A *superconducting*
 material exhibits no resistance to the flow of an electrical
 current. A related property, known as the Meissner effect,
 is that all magnetic field lines are excluded from the vol-
 ume of the material. **12.37** A *thin film* is a very thin

(0.1- to 300- μm) coating of a material deposited on a sub-
 strate. **12.39** A tantalum carbide thin film on a cutting
 tool should be heat- and fracture-resistant, adhere well to
 the metal substrate of the tool, have a uniform thickness,
 be of precisely known composition, and be free of imper-
 fections or dislocations. **12.41** Vacuum deposition,
 sputtering, and chemical vapor deposition. **12.43** In
 order to show liquid-crystalline behavior, a substance
 must be ordered in one or more directions. Molecules
 with strictly C—C backbones have so much flexibility
 that long-range ordering is unlikely, even in one direc-
 tion. **12.46** Because hydrogen bonding is a much
 stronger intermolecular interaction than London disper-
 sion forces, nylon has stronger interactions between poly-
 mer chains and is a harder material than polyethylene.

12.49 (a) Polymer; (b) ceramic; (c) ceramic; (d) poly-
 mer; (e) liquid crystal.



12.56 These compounds cannot be vaporized without
 destroying their chemical identities. Under the conditions
 of vacuum deposition, anions with names ending in *ite*
 or *ate* tend to chemically decompose to form gaseous
 nonmetal oxides.

Chapter 13

13.1 The solubility of a solute in a particular solvent de-
 pends on the strength of the “new” solute-solvent interac-
 tions relative to the strengths of “old” solute-solute and
 solvent-solvent interactions. **13.3** (a) Ion-dipole; (b)
 London dispersion; (c) hydrogen bonding; (d) dipole-
 dipole. **13.5** A solute is more likely to dissolve in a sol-
 vent if the strengths of the solute-solute, solvent-solvent,
 and solute-solvent interactions are similar. **13.7** (a)

There are no solute-solvent interactions between ionic
 KCl and nonpolar covalent C_6H_6 strong enough to com-
 pete with the ionic lattice forces in KCl. (b) Because the
 molar masses of CCl_4 and Br_2 are very similar, the Lon-
 don dispersion forces in Br_2 are more similar to those in
 CCl_4 . **13.9** (a) Since the solute and solvent in this case
 experience very similar London dispersion forces, the en-
 ergy required to separate them individually and the en-
 ergy released when they are mixed are approximately
 equal. $\Delta H_1 + \Delta H_2 \approx -\Delta H_3$. Thus, ΔH_{soln} is nearly zero.

(b) Since no strong intermolecular forces prevent the
 molecules from mixing, they do so spontaneously be-
 cause of the increase in disorder. **13.11** (a) 5.66%
 Na_2SO_4 by mass; (b) 5.5 ppm Au. **13.13** (a) $X_{\text{CH}_3\text{OH}} =$
 6.98×10^{-3} ; (b) $X_{\text{CH}_3\text{OH}} = 0.290$. **13.15** (a) 0.513 M
 NaCl; (b) 2.03 M $\text{LiClO}_4 \cdot 3\text{H}_2\text{O}$; (c) 0.120 M
 HNO_3 . **13.17** (a) 9.79 m C_6H_6 ; (b) 0.402 m NaCl.
13.19 (a) $X_{\text{CH}_3\text{OH}} = 0.205$; (b) 6.28 m CH_3OH ; (c)
 4.12 M CH_3OH . **13.21** (a) 41.1% H_2O by mass; (b)
 $X_{\text{H}_2\text{O}} = 0.691$; (c) 38.6 m H_2O ; (d) 21.1 M H_2O .
13.23 16 M HNO_3 . **13.25** (a) 2.61×10^{-2} mol MgCl_2 ;
 (b) 7.00×10^{-6} mol HCl; (c) 7.10×10^{-3} mol
 $(\text{NH}_4)_2\text{CrO}_4$. **13.27** (a) Weigh 2.50 g KBr, dissolve in
 water, dilute with stirring to 1.40 L. (b) Weigh 11.4 g
 KBr, dissolve in 238.6 g H_2O to make 250 g of solution.
 (c) Weigh 198 g KBr, dissolve in 1452 g H_2O to make
 1.50 L of solution. (d) Weigh 13.3 g KBr, dissolve in a
 small amount of H_2O , dilute to 0.560 L. **13.29** (a)

0.282 N; (b) 0.0675 M H_3PO_4 . **13.31** (a) A *saturated*
 solution is one that is in equilibrium with undissolved
 solute. (b) A *supersaturated* solution contains more dis-
 solved solute than is needed to form a saturated solution.
 (c) A supersaturated solution can be prepared by satur-
 ating a solution at high temperature and then carefully
 cooling it. **13.33** (a) Not saturated; (b) saturated; (c)
 saturated; (d) not saturated. **13.35** The aqueous solu-
 bility of most ionic solids increases with increasing tem-
 perature, and the solubility of most gases decreases with
 increasing temperature. **13.37** 9.2×10^{-4} M He, $1.5 \times$

cations migrate in the opposite direction. The electrode in the iron-containing beaker has a negative sign; that in the MnO_4^- beaker has a positive sign. (b) $E^\circ = 0.74 \text{ V}$. **20.71** (a) $2\text{Rh}^{3+}(\text{aq}) + 3\text{Cd}(\text{s}) \longrightarrow 2\text{Rh}(\text{s}) + 3\text{Cd}^{2+}(\text{aq})$; (b) anode, $\text{Cd}(\text{s})$; cathode, $\text{Rh}(\text{s})$; (c) $E_{\text{cathode}}^\circ = +0.80 \text{ V}$; (d) $\Delta G_{\text{cell}}^\circ = -695 \text{ kJ}$. **20.73** (a) Spontaneous; (b) nonspontaneous; (c) spontaneous; (d) nonspontaneous. **20.75** $E_{\text{cell}} = 0.033 \text{ V}$; the anode is in the compartment containing the dilute (0.040 M) $\text{Cr}^{3+}(\text{aq})$ solution. **20.78** $K_{\text{sp}} = 9.69 \times 10^{-13}$. **20.81** (a) $10 \text{ mol Cr}(\text{s})$ deposited, $5.9 \times 10^6 \text{ C}$ required; (b) $9.8 \times 10^5 \text{ amps}$. **20.83** (a) $1.2 \times 10^2 \text{ hr}$; (b) 20 kWh . **20.85** 732 g NaBO_3 . **20.87** (a) $w_{\text{max}} \approx 2 \text{ kWh}$; (b) This maximum amount of work is never realized because of internal resistance of the battery; because the cell voltage does not remain constant; because the vehicle is not capable of completely converting electrical energy into work. **20.89** The ship's hull should be made negative. The ship, as a negatively charged "electrode," becomes the site of reduction, rather than oxidation, in an electrolytic process.

Chapter 21

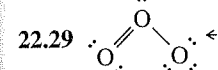
21.1 (a) 26 protons, 30 neutrons; (b) 38 protons, 50 neutrons; (c) 15 protons, 16 neutrons. **21.3** (a) ${}_{-1}^0\text{e}$; (b) ${}_{-1}^0\text{e}$; (c) ${}_{-1}^0\text{n}$. **21.5** (a) ${}_{53}^{131}\text{I} \longrightarrow {}_{54}^{131}\text{Xe} + {}_{-1}^0\text{e}$; (b) ${}_{90}^{230}\text{Th} \longrightarrow {}_{88}^{226}\text{Ra} + {}_{2}^4\text{He}$; (c) ${}_{74}^{181}\text{W} + {}_{-1}^0\text{e}$ (orbital electron) $\longrightarrow {}_{73}^{181}\text{Ta}$; (d) ${}_{7}^{13}\text{N} \longrightarrow {}_{6}^{13}\text{C} + {}_{+1}^0\text{e}$. **21.7** 4 alpha emissions, 4 beta emissions. **21.9** (a) Positron emission (for low atomic numbers, positron emission is more common than electron capture); (b) beta emission; (c) beta emission; (d) beta emission. **21.11** (a) No (low neutron/proton ratio, should be a positron emitter); (b) no (low neutron/proton ratio, should be a positron emitter or possibly undergo orbital electron capture); (c) no (high neutron/proton ratio, should be a beta emitter); (d) no (high atomic number, should be an alpha emitter). **21.13** (a) Stable: ${}_{39}^{90}\text{K}$, 20 neutrons is a magic number; (b) stable: ${}_{83}^{209}\text{Bi}$, 126 neutrons is a magic number; (c) stable: ${}_{12}^{24}\text{Mg}$, ${}_{10}^{20}\text{Ne}$ has a much higher neutron/proton ratio. **21.15** ${}_{2}^3\text{He}$, ${}_{8}^{16}\text{O}$, ${}_{20}^{40}\text{Ca}$. **21.17** Radioactive: (b), low neutron/proton ratio, (c), low neutron/proton ratio, and (e), atomic number greater than 83. Stable: (a) and (d). **21.19** Protons and alpha particles are positively charged and must be moving very fast to overcome electrostatic repulsions that would repel them from the target nucleus. Neutrons are electrically neutral and more easily captured by a target nucleus. **21.21** (a) ${}_{15}^{32}\text{P}$; (b) ${}_{3}^7\text{Li}$; (c) ${}_{75}^{187}\text{Re}$; (d) ${}_{43}^{99}\text{Tc}$; (e) ${}_{38}^{90}\text{Sr}$. **21.23** (a) ${}_{92}^{238}\text{U} + {}_{-1}^0\text{n} \longrightarrow {}_{92}^{239}\text{U} + {}_{0}^0\gamma$; (b) ${}_{7}^{14}\text{N} + {}_{1}^1\text{H} \longrightarrow {}_{6}^{12}\text{C} + {}_{2}^4\text{He}$; (c) ${}_{8}^{18}\text{O} + {}_{-1}^0\text{n} \longrightarrow {}_{9}\text{F} + {}_{-1}^0\text{e}$. **21.25** The suggestion is not reasonable. The energies of nuclear states are very large relative to ordinary temperatures. Merely changing the temperature by less than 100 K would not significantly affect the behavior of nuclei with regard to nuclear decay rates. **21.27** ${}_{31}^{68}\text{Ga} \longrightarrow {}_{30}^{68}\text{Zn} + {}_{+1}^0\text{e}$; $9.78 \times 10^{-6} \text{ g } {}^{68}\text{Ga}$ remain. **21.29** $k = 0.0307 \text{ yr}^{-1}$, $t_{1/2} = 22.6 \text{ yr}$. **21.31** Taking only the spontaneous radioactive decay of ${}^{131}\text{I}$ into account, the activity after 32 days should be 5.7

counts/min, which is the observed activity. The plants do not absorb iodide. **21.33** $4.0 \times 10^{-12} \text{ g } {}^{226}\text{Ra}$ decays in 1.0 min , 1.1×10^{10} alpha particles emitted. **21.35** $k = 1.21 \times 10^{-4} \text{ yr}^{-1}$; $1.70 \times 10^3 \text{ yr}$. **21.37** $k = 1.5 \times 10^{-10} \text{ yr}^{-1}$; the original rock contained $66.2 \text{ mg } {}^{238}\text{U}$ and is $1.9 \times 10^9 \text{ yr}$ old. **21.39** $9.317 \times 10^{-12} \text{ J/nucleon}$; $5.611 \times 10^{12} \text{ J/mol}$. **21.41** (a) $\Delta m = 8.25 \times 10^{-3} \text{ amu/nucleon}$; $\Delta E = 1.23 \times 10^{-12} \text{ J/nucleon}$; (b) $\Delta m = 9.41 \times 10^{-3} \text{ amu/nucleon}$; $\Delta E = 1.41 \times 10^{-12} \text{ J/nucleon}$; (c) $\Delta m = 8.46 \times 10^{-3} \text{ amu/nucleon}$; $\Delta m = 1.26 \times 10^{-12} \text{ J/nucleon}$. **21.43** $1.71 \times 10^5 \text{ kg/day}$; $2.10 \times 10^8 \text{ g } {}^{235}\text{U}$. **21.45** (a) ${}^{59}\text{Co}$; it has the largest binding energy per nucleon, and binding energy gives rise to mass defect. **21.47** (a) $4 {}_{-1}^0\text{n}$; (b) ${}_{36}^{92}\text{Kr}$. **21.49** The ${}^{59}\text{Fe}$ is incorporated into the diet component and fed to the rabbits. Blood samples are removed from the animals, the red blood cells separated, and the radioactivity of the sample measured. If the iron in the dietary compounds has been incorporated into blood hemoglobin, the blood cell sample should show beta emission. Samples can be taken at various times to determine the rate of iron uptake, rate of loss of iron from the blood, and so forth. **21.51** The extremely high temperature is required to overcome the electrostatic charge repulsions between the nuclei so that they can come together to react. **21.53** (a) Control rods control neutron flux so that there are enough neutrons to sustain the chain reaction but not so many that the core overheats. (b) A moderator slows neutrons so that they are more easily captured by fissioning nuclei. **21.55** The becquerel; the curie (Ci). **21.57** ${}_{84}^{210}\text{Po} \longrightarrow {}_{82}^{206}\text{Pb} + {}_{2}^4\text{He}$. **21.59** An electron. **21.62** (a) ${}_{17}^{36}\text{Cl} \longrightarrow {}_{18}^{36}\text{Ar} + {}_{-1}^0\text{e}$. (b) ${}^{36}\text{Cl}$ has an odd number of protons and neutrons (17p , 19n), and so it is less stable than the other two isotopes. **21.64** The source will last 1.69 yr ; it needs to be replaced in early July 1995. **21.68** 3.7×10^4 disintegrations/s; 4.8×10^{13} ${}^{90}\text{Sr}$ nuclei or $7.2 \times 10^{-9} \text{ g } {}^{90}\text{Sr}$. **21.71** 12 alpha particles (disintegrations)/s. **21.73** The mole fraction of ${}^3\text{H}$ atoms in the sample is 4.82×10^{-13} . **21.75** ${}^9\text{Be}$, $8.63 \times 10^{-13} \text{ J/nucleon}$; ${}^9\text{Be}$, $1.04 \times 10^{-12} \text{ J/nucleon}$; ${}^{10}\text{Be}$, $1.04 \times 10^{-12} \text{ J/nucleon}$. The binding energies per nucleon for ${}^9\text{Be}$ and ${}^{10}\text{Be}$ are very similar; the value for ${}^{10}\text{Be}$ is slightly higher.

Chapter 22

22.1 Metals: Sr, Ce, Rh; nonmetals: Se, Kr; metalloid: Sb. **22.3** Metals have high melting points and large thermal and electrical conductivity, whereas nonmetals have much lower melting points and are poor conductors. Metals react with nonmetals to produce ionic solids that melt at high temperatures; nonmetals react with other nonmetals to form covalent compounds that can be solids, liquids, or gases. Oxides of metals produce basic aqueous solutions, whereas oxides of nonmetals produce acidic aqueous solutions. **22.5** Bismuth should be the most metallic. It has a metallic luster and a relatively low ionization energy. Bi_2O_3 is soluble in acid but not in base, characteristic of the basic properties of the oxide of a metal rather than of the oxide of a nonmetal. **22.7** (a)

N; (b) K; (c) K in ionic form (e.g., K^+ in aqueous solution), Li in aqueous solution; (d) N has the smallest atomic radius, so it compares favorably with the other elements because it does not have to accommodate more than one bond readily form π bonds and it does not have to accommodate more than one bond readily form π bonds octet rule for both at lower electronegativity gives up electrons to be oxidized. **22.13** (a) $\text{Ni}(\text{s}) + 2\text{NiO}(\text{s}) + \text{C}(\text{s}) \longrightarrow 2\text{Ni}(\text{s}) + 3\text{H}_2\text{O}(\text{l}) + \text{Na}_2\text{S}(\text{s}) + 2\text{HCl}(\text{aq}) + 2\text{Cl}^-(\text{aq})$. **22.15** ${}^3\text{H}$ tritium. **22.17** Like group 7A, hydrogen has only one valence shell. **22.19** $\text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g}) \longrightarrow \text{Mg}(\text{s}) + 2\text{H}^+(\text{aq})$; (c) $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$. **22.21** (a) Ionic; (b) $\text{NaH}(\text{s}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2\text{SO}_4(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \longrightarrow 2\text{NaH}(\text{s})$; (e) $\text{PbO}(\text{s}) + \text{C}(\text{s}) \longrightarrow \text{Pb}(\text{s}) + \text{CO}(\text{g})$. **22.25** $7.9 \times 10^8 \text{ kg}$ steel making; to bleed torches; in medicine.



Ozone has two resonance structures, one of which is bent, with an $\text{O}-\text{O}$ double bond and a $\text{C}-\text{O}$ single bond; neither is a π bond, and so the $\text{O}-\text{O}$ bond is greater than the 1.48 \AA $\text{O}-\text{O}$ double bond length. **22.31** $\text{Ca}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \longrightarrow \text{Ca}(\text{OH})_2(\text{s})$; $2\text{Al}^{3+}(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{Al}(\text{OH})_3(\text{s}) + 3\text{H}^+(\text{aq})$; $2\text{Na}^+(\text{aq}) + 2\text{OH}^-(\text{aq}) \longrightarrow 2\text{NaOH}(\text{aq})$; $2\text{K}^+(\text{aq}) + 2\text{OH}^-(\text{aq}) \longrightarrow 2\text{KOH}(\text{aq})$; $\text{O}_3(\text{g}) \longrightarrow \text{NO}_2(\text{g}) + \text{O}(\text{g})$; acidic; (c) basic; the reactions occur: $\text{S}^{2-}(\text{aq}) \longrightarrow 2\text{OH}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$; $\text{NO}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{As}_2\text{O}_3(\text{s}) + 2\text{H}_2\text{O}(\text{l})$; $5\text{H}_2\text{O}(\text{l})$. (e) This solution, because Fe^{2+} were basic. $2\text{Fe}^{2+}(\text{aq}) + 2\text{Fe}^{3+}(\text{aq}) + 2\text{H}_2\text{C}(\text{aq}) \longrightarrow 2\text{Fe}(\text{s}) + \text{NH}_3$, and fertilizer.