e. $O_2(g) + 2H_2SO_3(aq) \longrightarrow 2SO_4^{2-}(aq) + 4H^+(aq)$

Oxidation half-reaction:

$H_2SO_3(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$

Reduction half-reaction:

$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

$E^0_{cell} =$

$+1.229\ V - (+0.172\ V) = +1.057\ V$

Spontaneous?

yes

5. Suppose a battery-powered device requires a minimum voltage of 9.0 V to run. How many lead–acid cells would be needed to run the device? (Remember that a standard automobile battery contains six lead–acid cells connected in one package.) The overall reaction of a lead–acid cell is

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$$

$E^0_{cell} = +1.6913\ V - (-0.3588\ V) = +2.0501\ V$

9.0 V/2.0501 V = 4.4

At least 5 lead–acid cells would be needed to run the device.

6. What is the minimum voltage that must be applied to a Down's cell to cause the electrolysis of molten sodium chloride? The net cell reaction is

$$2Na^+(l) + 2Cl^-(l) \longrightarrow 2Na(l) + Cl_2(g)$$

$E^0_{cell} = +1.35827\ V - (-2.71\ V) = +4.06827\ V$; round to $+4.07$ V

The minimum voltage to cause electrolysis is -4.07 V.

7. One way to determine the metallic composition of an alloy is to use electroplating. Suppose an electrolytic cell is set up with solution of nickel ions obtained from a 6.753-g sample of a nickel alloy. The cell also contains a platinum electrode that has a mass of 10.533 g. Electric current is used to reduce the nickel ions to nickel metal, which is deposited on the platinum electrode. After being plated with nickel, the platinum electrode has a mass of 15.042 g. What is the percentage of nickel in the alloy?

$$100\% \times \frac{(15.042\ g - 10.533\ g)}{6.753\ g} = 66.77\%$$

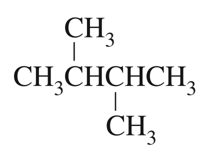
Chapter 22

1. Use the IUPAC rules to name the following alkanes.

a. $CH_3CH_2CH_2CH_2CH_3$

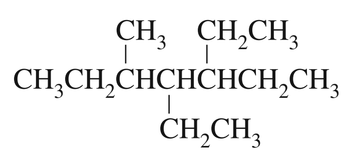
pentane

b.



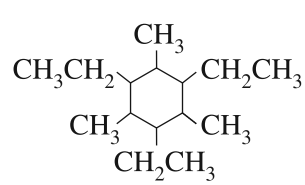
2,3-dimethylbutane

c.



3,4-diethyl-5-methylheptane

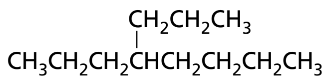
d.



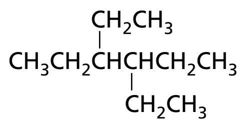
1,3,5-triethyl-2,4,6-trimethylcyclohexane

2. Draw the structure of each of the following alkanes.

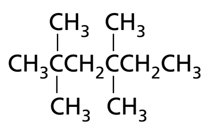
a. 4-propyloctane



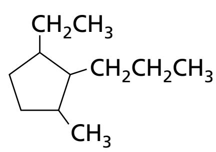
b. 3,4-diethylhexane



c. 2,2,4,4-tetramethylhexane



d. 1-ethyl-3-methyl-2-propylcyclopentane



3. Calculate the number of hydrogen atoms in each of the following alkanes.

a. heptane

Straight-chain alkanes have the formula C_nH_{2n+2}. In heptane, $n = 7$, so the number of hydrogen atoms = $(2 \times 7) + 2 = 16$.

b. cyclooctane

Cyclic alkanes with one ring have the same number of hydrogen atoms as straight-chain alkanes, less two hydrogen atoms lost when the ring is formed. In cyclooctane, $n = 8$, so the number of hydrogen atoms = $(2 \times 8) + 2 - 2 = 16$.

4. Calculate the molecular mass of a 22-carbon branched-chain alkane.

Branched-chain alkanes have the formula C_nH_{2n+2}.
If $n = 22$, the number of hydrogen atoms = $(2 \times 22) + 2 = 46$.

22 atoms C	22×12.011 amu =	264.24 amu
46 atoms H	46×1.008 amu =	46.37 amu
molecular mass		310.61 amu

5. Chemists can analyze the composition of hydrocarbons by reacting them with copper oxide. The reaction converts carbon into carbon dioxide and hydrogen into water. Suppose 29 g of a hydrocarbon reacts to produce 88 g of CO_2 and 45 g of H_2O.

a. What are the masses of carbon and hydrogen in the hydrocarbon?

All of the carbon in CO_2 and all of the hydrogen in H_2O come from the hydrocarbon.

molecular mass $CO_2 = (1 \times 12.0 \text{ amu}) + (2 \times 16.0 \text{ amu}) = 44.0$ amu

mass C = 88 g $CO_2 \times$ (12 g C/44 g CO_2) = 24 g

molecular mass $H_2O = (2 \times 1.0 \text{ amu}) + (1 \times 16.0 \text{ amu}) = 18.0$ amu

mass H = 45 g $H_2O \times$ (2.0 g C/18 g H_2O) = 5.0 g

b. What is the empirical formula of the hydrocarbon?

24 g C × (1 mole C/12 g C) = 2 moles C

5 g H × (1 mole H/1 g H) = 5 moles H

The empirical formula is C_2H_5.

c. If the hydrocarbon's molecular mass is 58 amu, what is its molecular formula?

The empirical formula (C_2H_5) corresponds to a molecular mass of $(2 \times 12 \text{ amu}) + (5 \times 1 \text{ amu}) = 29$ amu. Since $\frac{58 \text{ amu}}{29 \text{ amu}} = 2$, the molecular formula must be twice the empirical formula, or C_4H_{10}.

6. Carbon has an electronegativity of 2.5. Hydrogen has an electronegativity of 2.2. Use these values to decide whether each of the following bonds is polar or nonpolar.

a. C-C

2.5 − 2.5 = 0. Since the difference is less than 0.5, the bond is nonpolar.

b. C-H

2.5 − 2.2 = 0.3. Since the difference is less than 0.5, the bond is nonpolar.

c. H-H

2.2 − 2.2 = 0. Since the difference is less than 0.5, the bond is nonpolar.

7. The combustion of a saturated hydrocarbon releases 657 kJ per mole of $–CH_2–$ groups and 779 kJ per mole of $–CH_3$ groups in the hydrocarbon. How much energy is released by the combustion of 1.00 L of liquid tetradecane (molecular formula $C_{14}H_{30}$), a major component of kerosene? The density of tetradecane is 0.764 g/mL.

14 atoms C	14 × 12.011 amu =	168.15 amu
30 atoms H	30 × 1.008 amu =	30.24 amu
molecular mass		198.39 amu

1.00 L × (10^3 mL/1 L) × (0.764 g/mL) × (1 mole/198.39 g) = 3.85 moles tetradecane

Each molecule of tetradecane has 12 $–CH_2–$ groups and 2 $–CH_3$ groups.

3.85 moles tetradecane × (12 moles $–CH_2–$/mole tetradecane) × (657 kJ/mole $–CH_2–$) = 30 400 kJ

3.85 moles tetradecane × (2 moles $–CH_3$/mole tetradecane) × (779 kJ/mole $–CH_3$) = 6000 kJ

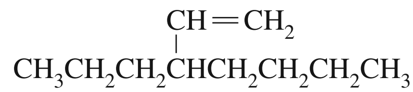
30 400 kJ + 6000 kJ = 36 400 kJ = 3.64×10^4 J

8. Use the IUPAC rules to name the following hydrocarbons.

a. $CH_3CH_2CH{=}CHCH_3$

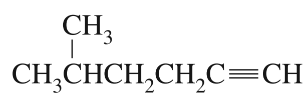
2-pentene

b.



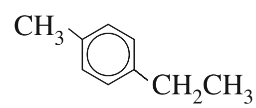
3-propyl-1-heptene

c.



5-methyl-1-hexyne

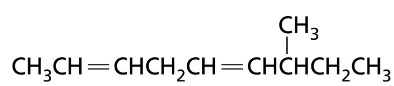
d.



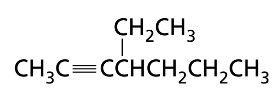
1-ethyl-4-methylbenzene

9. Draw the structure of each of the following hydrocarbons.

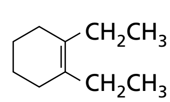
a. 7-methyl-2,5-nonadiene



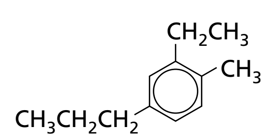
b. 4-ethyl-2-heptyne



c. 1,2-diethylcyclohexene



d. 1-ethyl-2-methyl-5-propylbenzene



10. Calculate the number of hydrogen atoms in each of the following unsaturated hydrocarbons.

a. 2-pentene

Alkenes with one double bond have the formula C_nH_{2n}. In 2-pentene, $n = 5$, so the number of hydrogen atoms $= 2 \times 5 = 10$.

b. 1-hexyne

Alkynes with one triple bond have the formula C_nH_{2n-2}. In 1-hexyne, $n = 6$, so the number of hydrogen atoms $= (2 \times 6) - 2 = 10$.

11. Write a balanced equation for the reaction in which calcium carbide, CaC_2, reacts with water to form ethyne and calcium hydroxide.

$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$

Chapter 24

1. Calculate the molecular masses of the following biological molecules.

a. Lysine, $NH_2(CH_2)_4CHNH_2COOH$

6 atoms C	6×12.0 u =	72.0 u
14 atoms H	14×1.0 u =	14.0 u
2 atoms O	2×16.0 u =	32.0 u
2 atoms N	2×14.0 u =	28.0 u
molecular mass		146.0 u

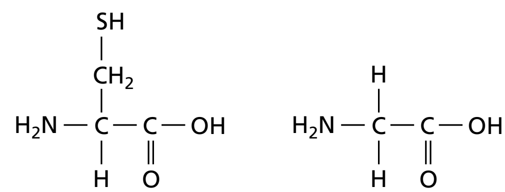
b. Fructose, $CH_2OHCO(CHOH)_3CH_2OH$

6 atoms C	6×12.0 u =	72.0 u
12 atoms H	12×1.0 u =	12.0 u
6 atoms O	6×16.0 u =	96.0 u
molecular mass		180.0 u

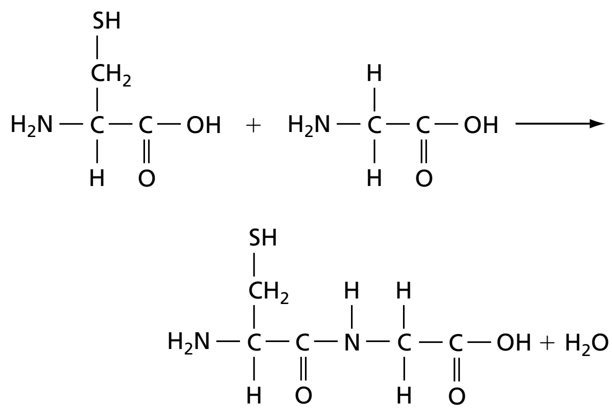
c. Oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$

18 atoms C	18×12.0 u =	216.0 u
34 atoms H	34×1.0 u =	34.0 u
2 atoms O	2×16.0 u =	32.0 u
molecular mass		282.0 u

2. Write a balanced equation for the condensation reaction in which cysteine and glycine combine to form a dipeptide. Assume the carboxyl group of cysteine reacts.



cysteine glycine



3. In a peptide or protein that contains *n* amino acids, the number of possible amino acid sequences is A^n, where *A* is the number of different amino acids.

a. How many amino acid sequences are possible for a polypeptide that contains 10 amino acids?

$A = 20$, so the number of possible amino acid sequences $= 20^{10} = 1.024 \times 10^{13}$.

b. How many different dipeptides can be made from the amino acids leucine (Leu) and valine (Val)? What are those dipeptides?

$A = 2$, so the number of different dipeptides $= 2^2 = 4$. The dipeptides are Leu-Leu, Leu-Val, Val-Leu, and Val-Val.