FINAL EXAM

PRACTICE PROBLEMS

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Chemistry 165b | Spring 2019

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KINETICS: PROBLEM 1.1

Consider the reaction between nitrogen monoxide and hydrogen gases:

$$2\ NO\ (g) + 2\ H_2\ (g) \rightarrow N_2\ (g) + 2\ H_2O\ (g)$$

Given the following initial rates data collected at 300 K, determine the rate law for the reaction.

Expt.	$[NO]_0$ (M)	$[H_2]_0$ (M)	Initial Rate (M/min)
1	0.0060	0.0010	1.8×10^{-4}
2	0.0060	0.0020	3.6×10^{-4}
3	0.0010	0.0060	3.0×10^{-5}
4	0.0020	0.0060	1.2×10^{-4}

– answer –

KINETICS: PROBLEM 1.2

Consider the reaction between nitrogen monoxide and hydrogen gases:

$$2\ NO\ (g) + 2\ H_2\ (g) \rightarrow N_2\ (g) + 2\ H_2O\ (g)$$

Given the following initial rates data collected at 300 K, determine the rate constant *k* (value and units) for the reaction.

Expt.	$[NO]_0$ (M)	$[H_2]_0$ (M)	Initial Rate (M/min)
1	0.0060	0.0010	1.8×10^{-4}
2	0.0060	0.0020	3.6×10^{-4}
3	0.0010	0.0060	3.0×10^{-5}
4	0.0020	0.0060	1.2×10^{-4}

– answer –

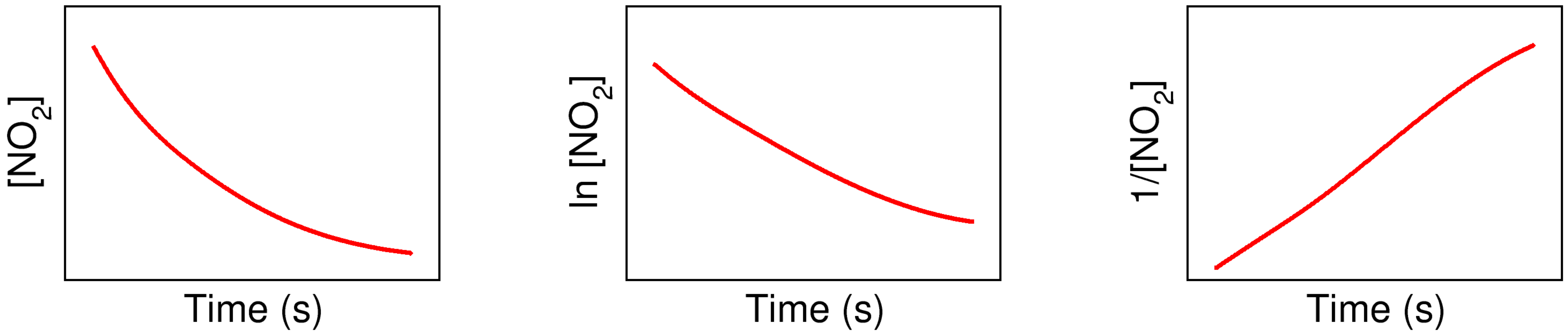
KINETICS: PROBLEM 1.3

The following concentration-time data are plotted below for the decomposition of nitrogen dioxide gas at 298 K.

$$2\ NO_2\ (g) \rightarrow 2\ NO\ (g) + O_2\ (g)$$

What is the order of the reaction with respect to $[NO_2]$?

Time (s)	$[NO_2]$ (M)
10.	0.0044
26.	0.0034
44.	0.0027
70.	0.0020
120.	0.0014



— answer —

KINETICS: PROBLEM 1.4

Consider the decomposition of NO_2 (g) from Problem 1.3:

$$2\ NO_2\ (g) \rightarrow 2\ NO\ (g) + O_2\ (g)$$

Which of the following proposed mechanism(s) is (are) not valid?

Justify your choice briefly.

– answer –

(i)
$NO_2 \rightarrow NO + O$ (slow)
$NO_2 + O \rightarrow NO + O_2$ (fast)

(ii)
$NO_2 + NO_2 \rightleftharpoons N_2O_4$ (fast)
$N_2O_4 \rightarrow NO + NO_3$ (slow)
$NO_3 \rightarrow NO + O_2$ (fast)

(iii)
$NO_2 + NO_2 \rightarrow NO + NO_3$ (slow)
$NO_3 \rightarrow NO + O_2$ (fast)

KINETICS: PROBLEM 1.5

Consider the decomposition of NO_2 (g) from Problem 1.3 and 1.4: $2\ NO_2\ (g) \rightarrow 2\ NO\ (g) + O_2\ (g)$

The initial concentration of $[NO_2]_0 = 5.56 \times 10^{-3}$ M. After 500 s have elapsed, the concentration of NO_2 is 4.14×10^{-4} M.

Calculate the rate constant *k* (value and units) for the reaction.

– answer –

EQUILIBRIUM: PROBLEM 2.1

Consider the following gaseous equilibrium: $2\ H_2S\ (g) \rightleftharpoons 2\ H_2\ (g) + S_2\ (g)$

A 10.0 L vessel contains 10.0 atm of H_2S gas at 800 K initially. If the partial pressure of S_2 gas is 0.020 atm at equilibrium, what is the value of K_c?

– answer –

EQUILIBRIUM: PROBLEM 2.2

Which of the following changes would increase the concentration of $[H_2]$ in the following chemical equilibrium?

$$C\ (s) + H_2O\ (g) \rightleftharpoons CO\ (g) + H_2\ (g) \qquad ; \Delta H = +131\ \text{kJ}$$

— answer —

ACID-BASE: PROBLEM 3.1

Benzoic acid (C_6H_5COOH) is a weak acid with a $K_a = 6.25 \times 10^{-5}$ at 298 K.

What is the pH of a 125 mL solution of 0.10 M C_6H_5COOH?

– answer –

ACID-BASE: PROBLEM 3.2

Hydrazoic acid (N_3H) is a weak acid with a $K_\mathrm{a} = 1.9 \times 10^{-5}$ at 298 K.

To 100. mL of 0.25 M N_3H we add 0.50 g of NaOH. What is the pH of the resulting solution?

You may assume no change in volume or temperature.

— answer —

ACID-BASE: PROBLEM 3.3

A buffer with pH = 4.87 is made from 10.0 mL of 0.75 M acetic acid (CH_3COOH) and 5.0 mL of 2.0 M sodium acetate ($NaCH_3COO$). Acetic acid is a weak acid with a $K_a = 1.8 \times 10^{-5}$ at 298 K.

Calculate the pH of the solution if 0.00010 mol of NaOH are added to the buffer.

You may assume no change in volume or temperature.

— answer —

THERMODYNAMICS: PROBLEM 4.1

Consider the following reaction:

$$CaSO_4{\cdot}2H_2O\ (s) \rightarrow CaSO_4\ (s) + 2\ H_2O\ (g)$$

Given the following thermodynamic data at 25 °C, calculate the standard Gibbs free energy change ($\Delta G^{o}_{\mathrm{rxn}}$) at 25 ° C.

	$CaSO_4{\cdot}2H_2O$ (s)	$CaSO_4$ (s)	H_2O (g)
$\Delta G^{o}_{\mathrm{f}}\ \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−1797.4	−1322.0	−228.6
$\Delta H^{o}_{\mathrm{f}}\ \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−2022.6	−1434.5	−241.8
$S^{\circ}\ \left(\frac{\mathrm{J}}{\mathrm{mol}\cdot\mathrm{K}}\right)$	194.1	106.5	188.8

— answer —

There are two ways to find the value of $\Delta G^{o}_{\mathrm{rxn}}$:

THERMODYNAMICS: PROBLEM 4.2

Consider the following decomposition reaction:

$$2\ HgO\ (s) \rightarrow 2\ Hg\ (l) + O_2\ (g)$$

Given the following thermodynamic data at 25 °C, determine if the decomposition reaction is spontaneous at 800 K.

	HgO (s)	Hg (l)	O_2 (g)
$\Delta G_f^o \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−58.5	0	0
$\Delta H_f^o \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−90.83	0	0
$S^\circ \left(\frac{\mathrm{J}}{\mathrm{mol \cdot K}}\right)$	70.29	75.9	205.0

– answer –

ELECTROCHEMISTRY: PROBLEM 5.1

Using the following table of standard reduction potentials, which of the following redox reactions represent spontaneous reactions taking place in a voltaic/Galvanic cell?

Half-reaction	$E°$ (V)
Ag^{+} (aq) + e^{-} → Ag (s)	+0.800
Sn^{2+} (aq) + 2 e^{-} → Sn (s)	−0.136
Ni^{2+} (aq) + 2 e^{-} → Ni (s)	−0.257
Mn^{2+} (aq) + 2 e^{-} → Mn (s)	−1.185
Al^{3+} (aq) + 3 e^{-} → Al (s)	−1.662
Na^{+} (aq) + e^{-} → Na (s)	−2.710

— answer —

	Redox Reaction	Spontaneous?
(a)	Mn (s) + Sn^{2+} (aq) → Mn^{2+} (aq) + Sn (s)	
(b)	Mn (s) + Ni^{2+} (aq) → Mn^{2+} (aq) + Ni (s)	
(c)	Mn (s) + 2 Na^{+} (aq) → Mn^{2+} (aq) + 2 Na (s)	
(d)	3 Mn (s) + 2 Al^{3+} (aq) → 3 Mn^{2+} (aq) + 2 Al (s)	
(e)	Mn (s) + 2 Ag^{+} (aq) → 3 Mn^{2+} (aq) + 2 Ag (s)	

ELECTROCHEMISTRY: PROBLEM 5.2

A voltaic/Galvanic cell is made from a compartment with 1.20 M $Fe(NO_3)_3$ and 1.10 M $Fe(NO_3)_2$, a compartment with 0.95 M $Cr(NO_3)_2$ and 1.00 M $Cr(NO_3)_3$, both at 25 °C, connected by a wire, salt bridge, and two platinum electrodes.

Calculate the initial potential of this cell.

Half-reaction	$E°$ (V)
Fe^{3+} (aq) + e^- → Fe^{2+} (aq)	+0.770
Cr^{3+} (aq) + e^- → Cr^{2+} (aq)	–0.410
Fe^{2+} (aq) + 2 e^- → Fe (s)	–0.447
Cr^{3+} (aq) + 3 e^- → Cr (s)	–0.740

– answer –

ELECTROCHEMISTRY: PROBLEM 5.3

Sodium metal (Na) can be obtained by electrolyzing molten NaCl. What mass of sodium metal can be produced when molten NaCl is electrolyzed for 10.3 hours with 5.13 A of current?

— answer —

Half-reaction	$E°$ (V)
Cl_2 (g) + 2 e^- → 2 Cl^- (aq)	+1.358
Na^+ (aq) + e^- → Na (s)	−2.710

NUCLEAR CHEMISTRY: PROBLEM 6.1

For each of the following nuclides, predict the types of radioactive decay and reactants/products of such decays.

– answer –

	Nuclide
(a)	^{37}Ca
(b)	^{34}P
(c)	^{212}Fr
(d)	^{129}Sb

NUCLEAR CHEMISTRY: PROBLEM 6.2

A ^{8}B nuclide decays into a ^{8}Be nuclide through positron emission. Calculate the energy produced from this type of radioactive decay based on the following masses: ^{8}B (8.02460 amu), ^{8}Be (8.00530 amu), and ${}^{0}_{+1}\beta$ (0.00055 amu).

Recall: $1 \text{ amu} = 1.6605 \times 10^{-27} \text{ kg}$ $c = 3.00 \times 10^{8} \text{ m/s}$ $1\ \text{J} = 1\ \text{kg} \cdot \text{m}^2/\text{s}^2$

— answer —

NUCLEAR CHEMISTRY: PROBLEM 6.3

A piece of paper from an ancient scroll undergoes ^{14}C-decay with a rate of 9.07 decays/min. A fresh piece of paper also undergoes ^{14}C-decay but with a rate of 13.6 decays/min. If the half-life for ^{14}C-decay is 5730 years, how old is the scroll?

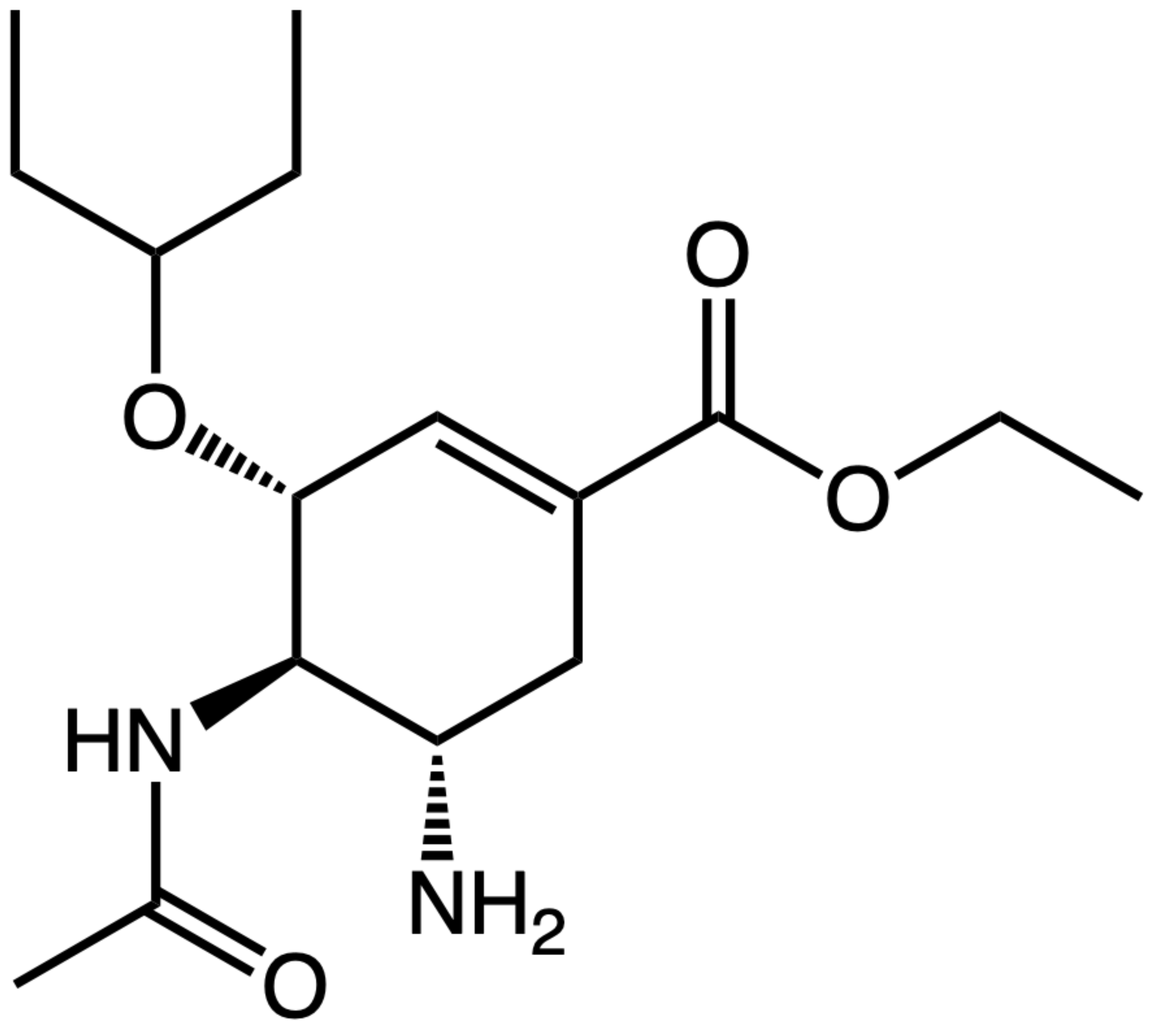
– answer –

ORGANIC CHEMISTRY: PROBLEM 7.1

For the two compounds shown below, identify if the following functional groups are present.

— answer —

	Functional Group
(a)	Alcohol
(b)	Amide
(c)	Carboxylic Acid
(d)	Amine
(e)	Ester
(f)	Alkyne
(g)	Ether
(h)	Alkene
(i)	Aldehyde
(j)	Ketone



	Functional Group
(a)	Alcohol
(b)	Amide
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(d)	Amine
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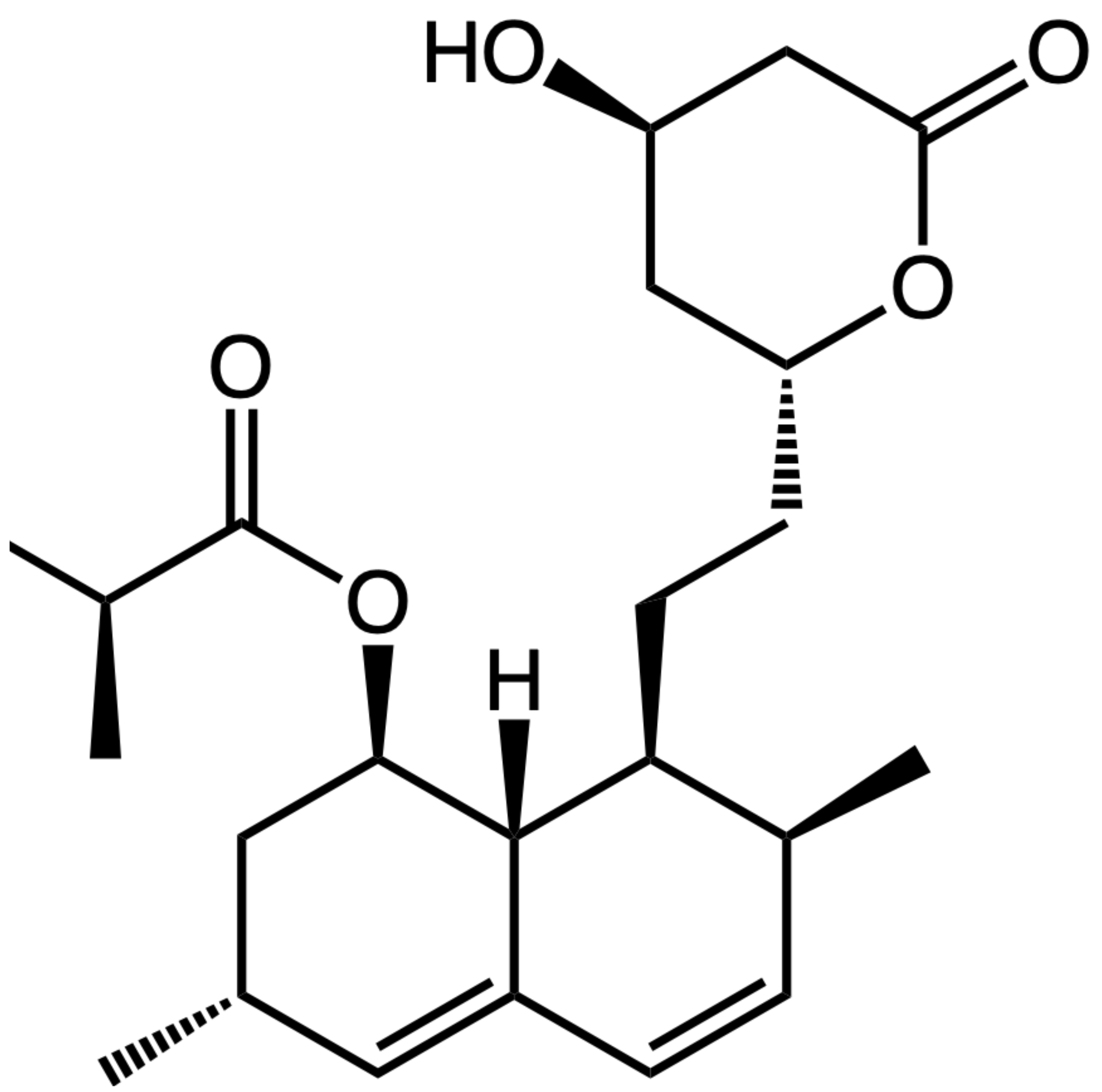
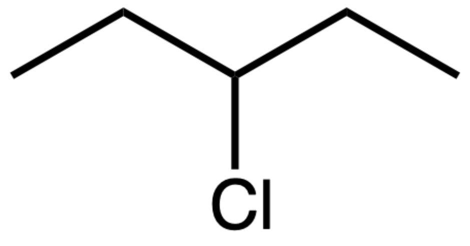


ORGANIC CHEMISTRY: PROBLEM 7.2

Choose the possible product(s) for the reaction between pentane and Cl_2 using UV radiation.

— answer —



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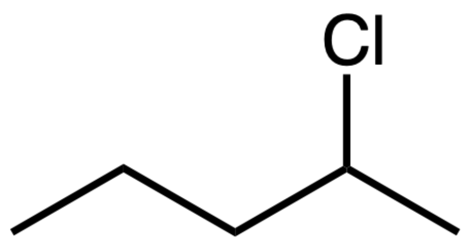

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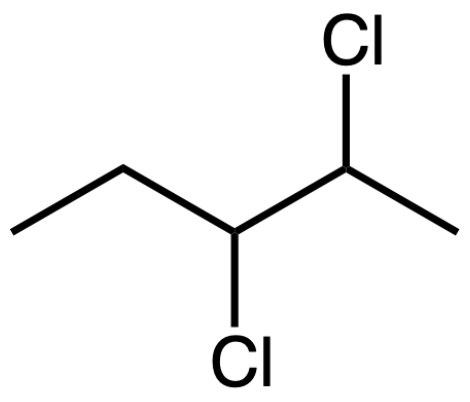

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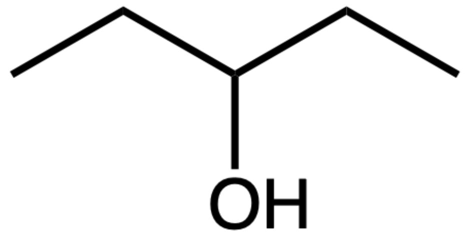

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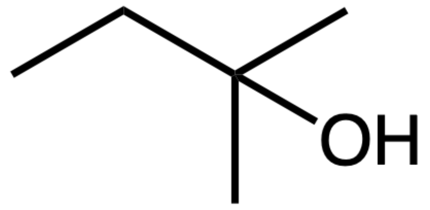

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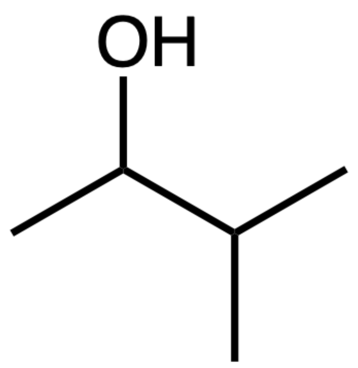

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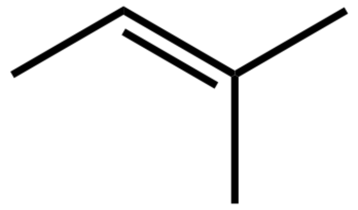

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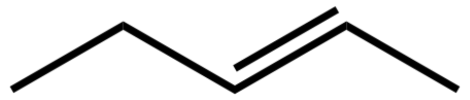

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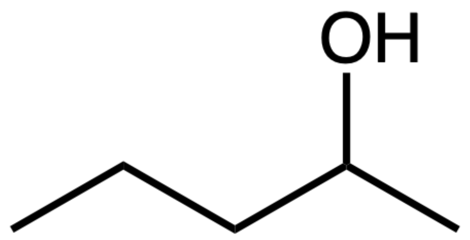

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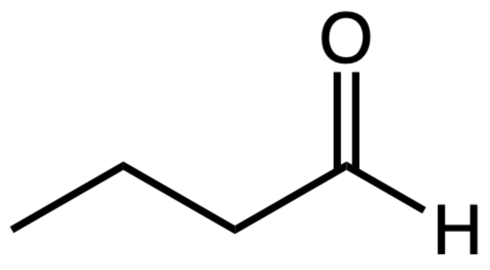

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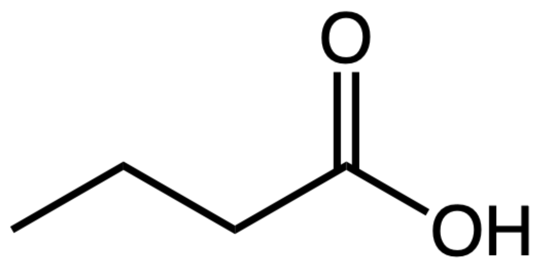

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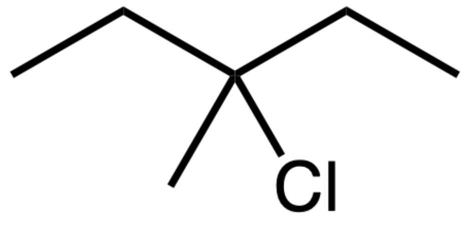

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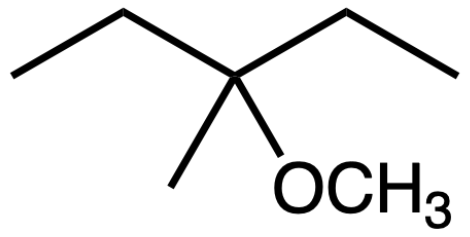

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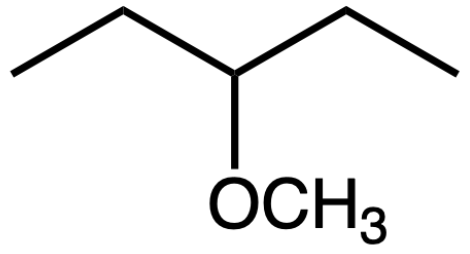

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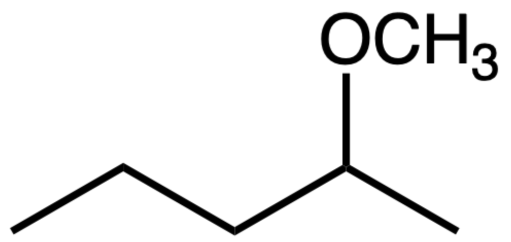

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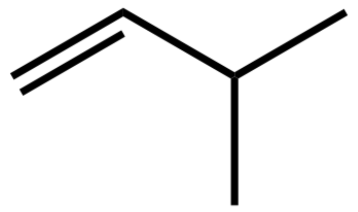

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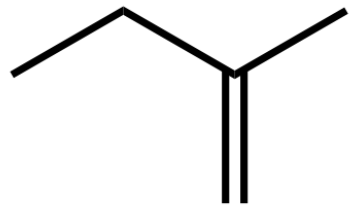

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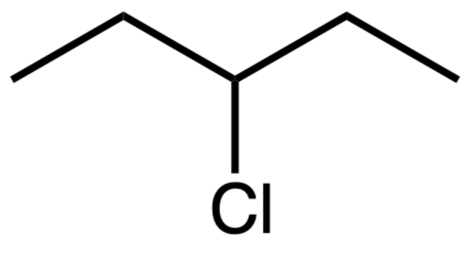
ORGANIC CHEMISTRY: PROBLEM 7.3

Choose the possible product(s) for the addition reaction between 2-pentene and Cl_2.

— answer —



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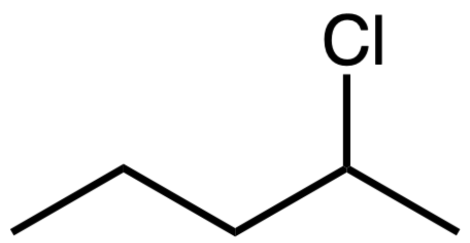

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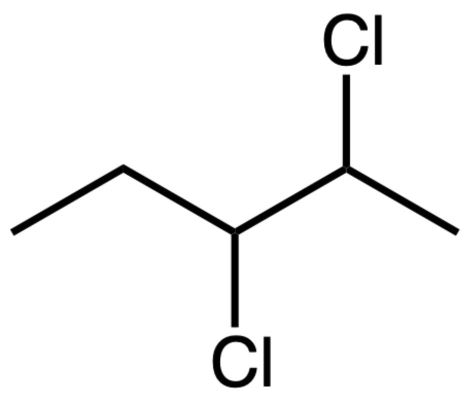

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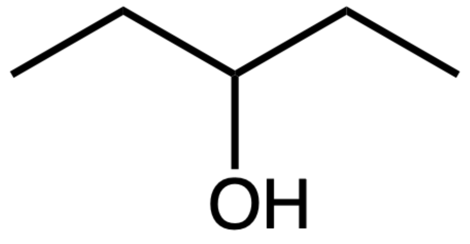

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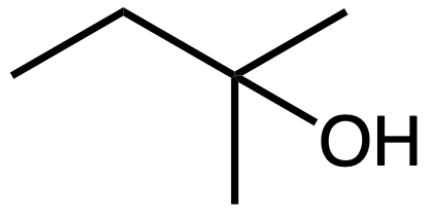

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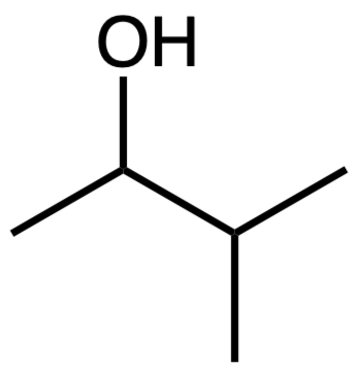

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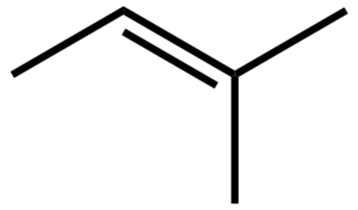

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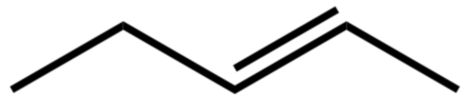

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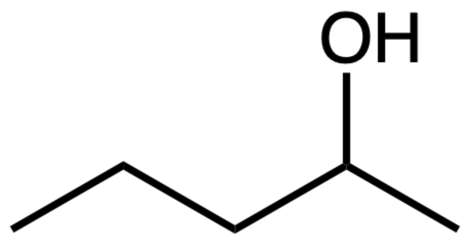

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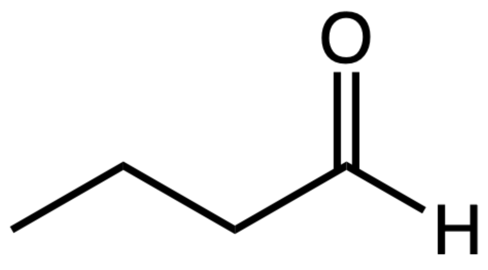

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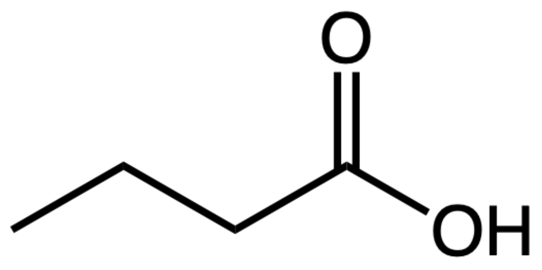

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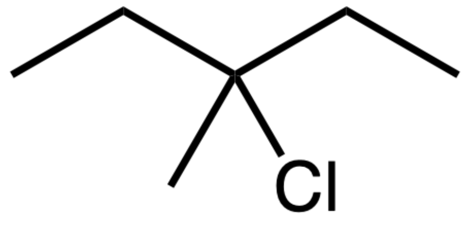

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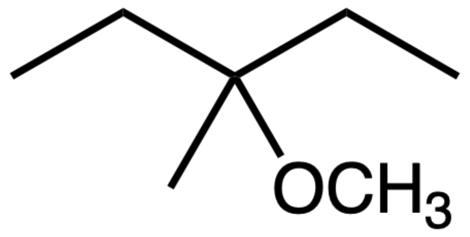

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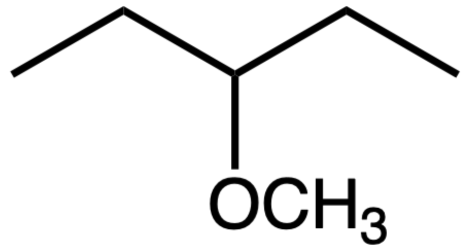

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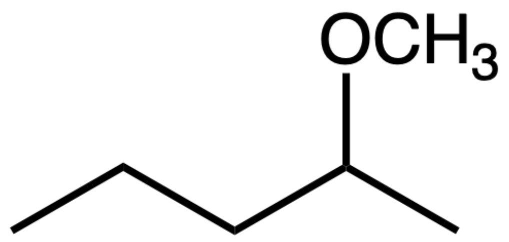

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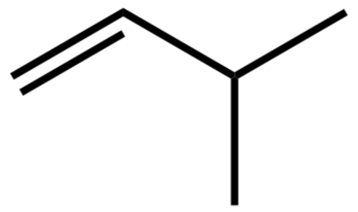

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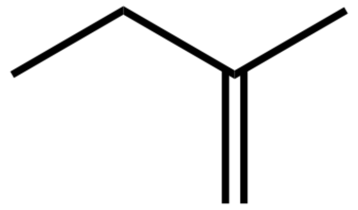

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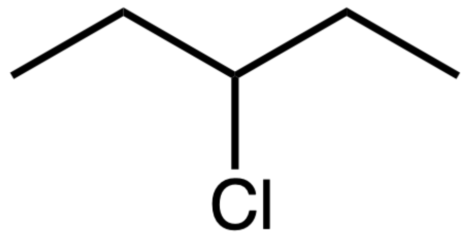
ORGANIC CHEMISTRY: PROBLEM 7.4

Choose the possible product(s) for the addition reaction between 2-pentene and HCl.

— answer —



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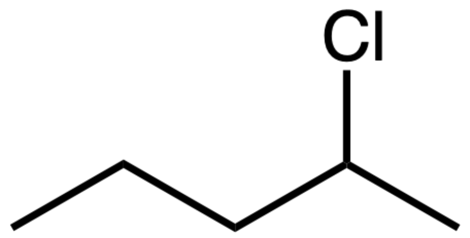

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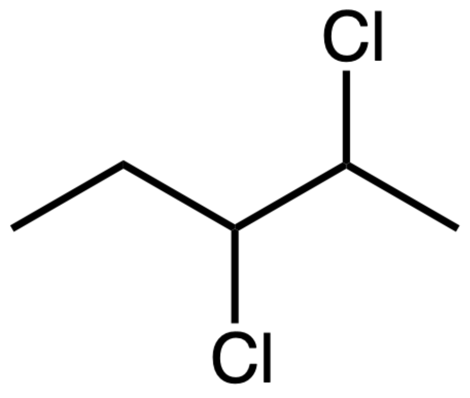

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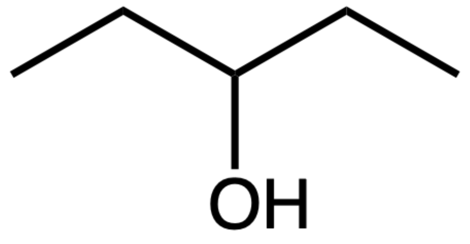

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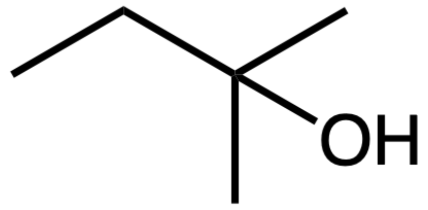

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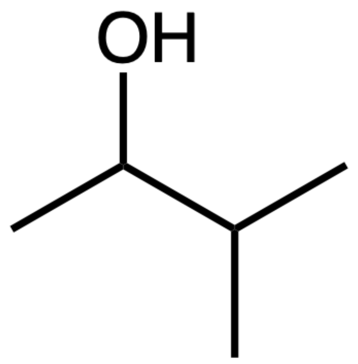

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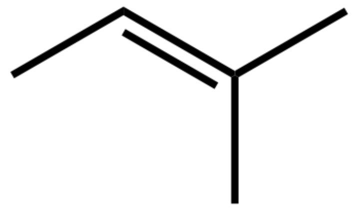

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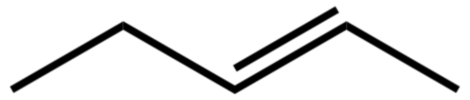

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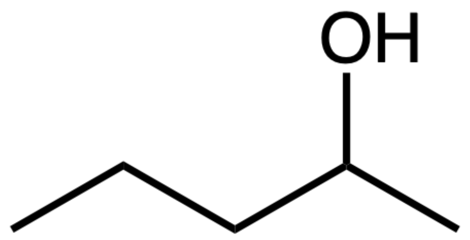

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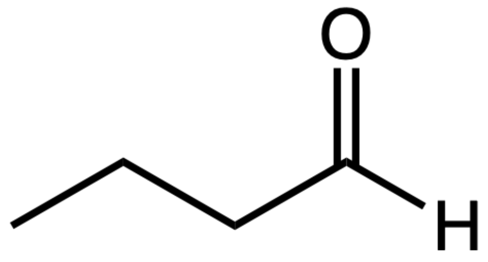

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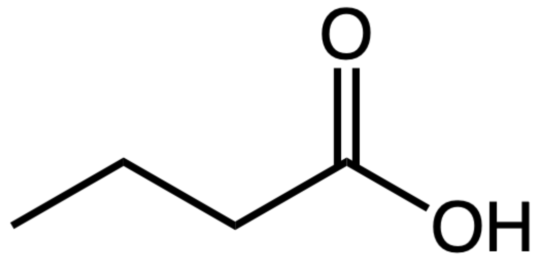

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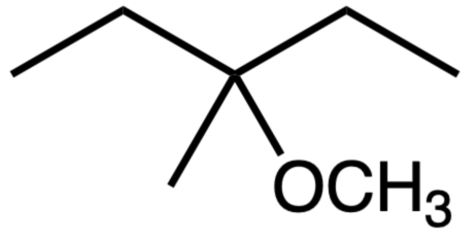

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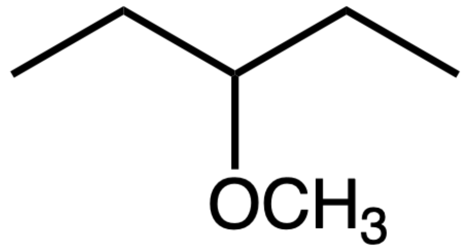

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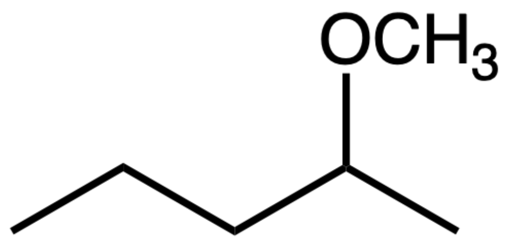

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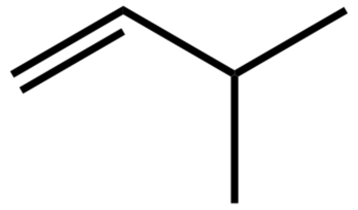

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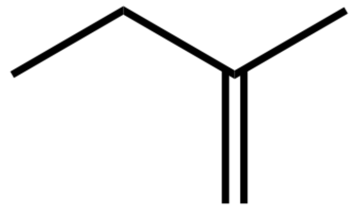

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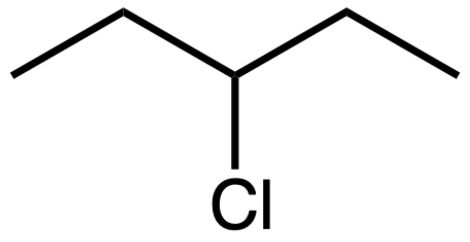
ORGANIC CHEMISTRY: PROBLEM 7.5

Choose the possible product(s) for the addition reaction between 2-methyl-2-butene, water, and an acid catalyst.

— answer —



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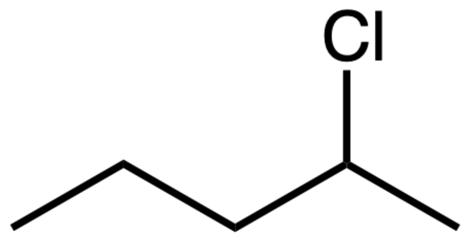

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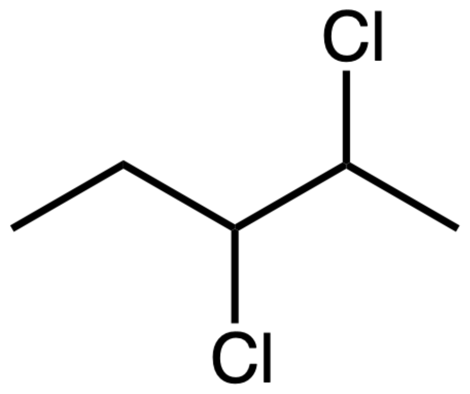

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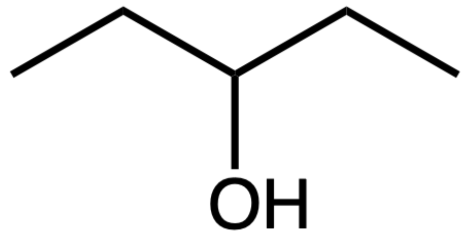

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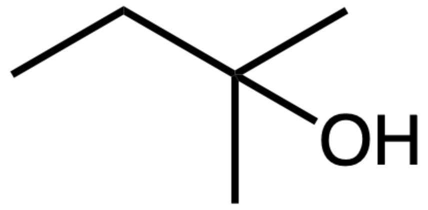

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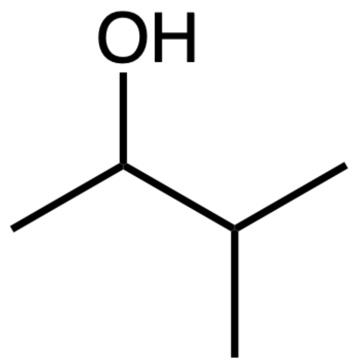

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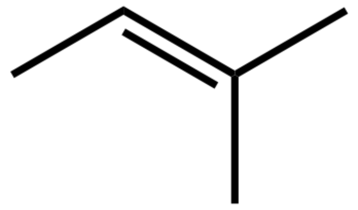

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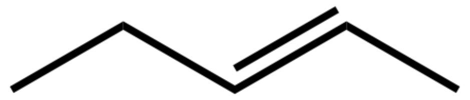

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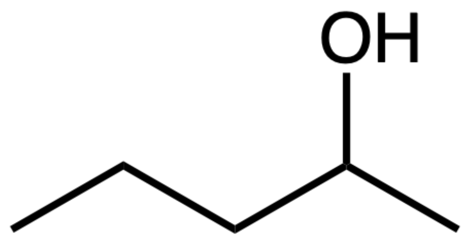

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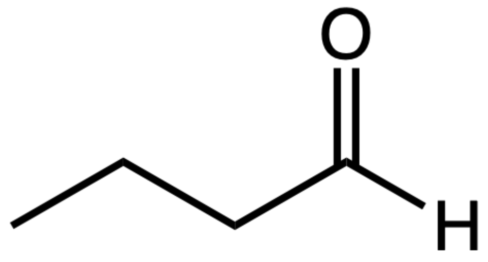

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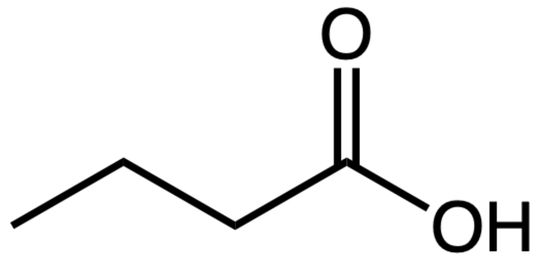

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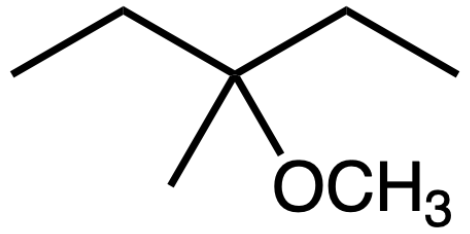

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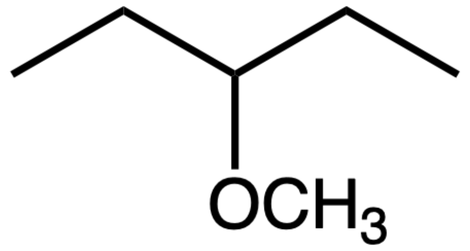

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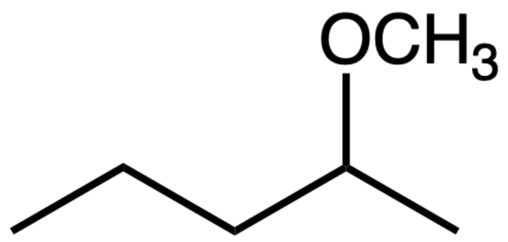

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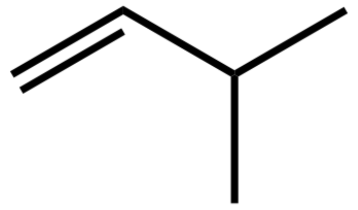

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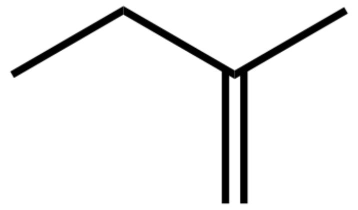

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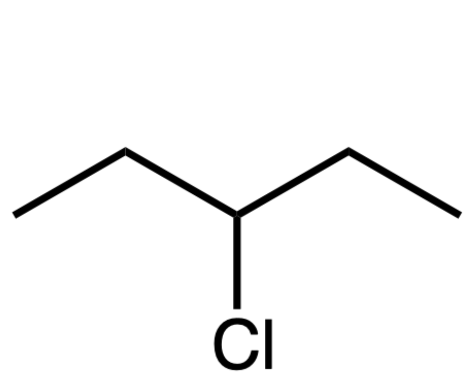
ORGANIC CHEMISTRY: PROBLEM 7.6

Which of the following compounds could be oxidized to produce a ketone?

— answer —



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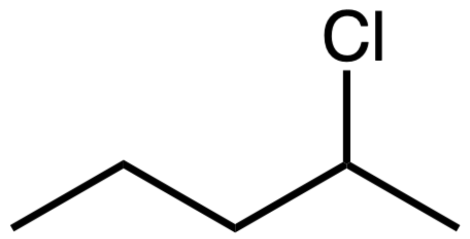

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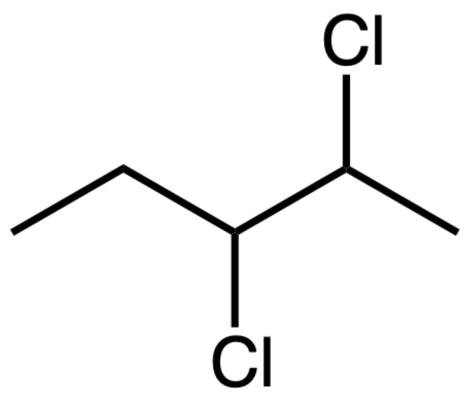

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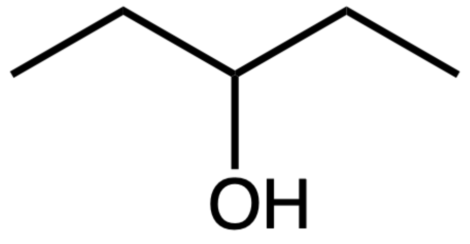

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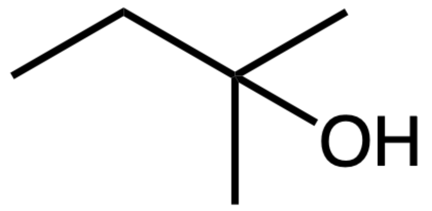

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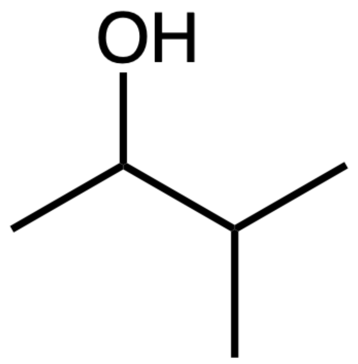

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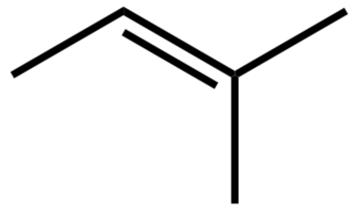

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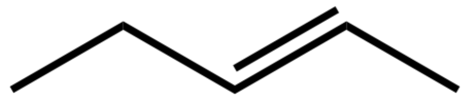

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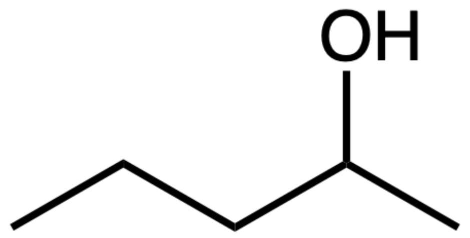

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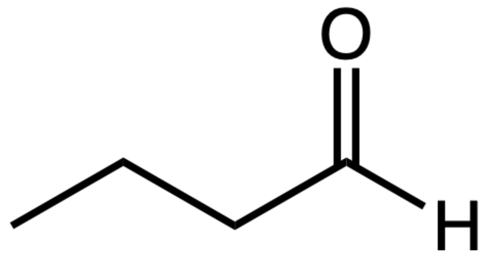

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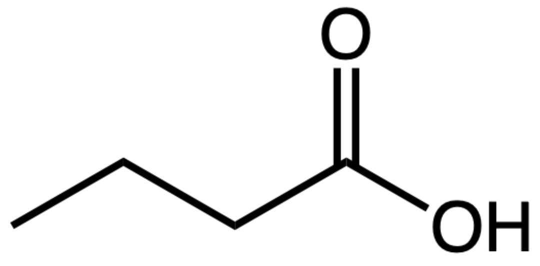

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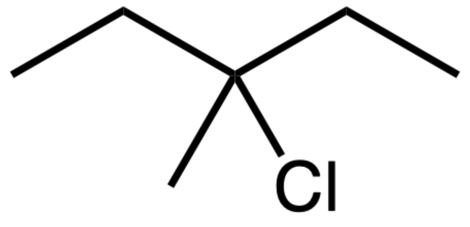

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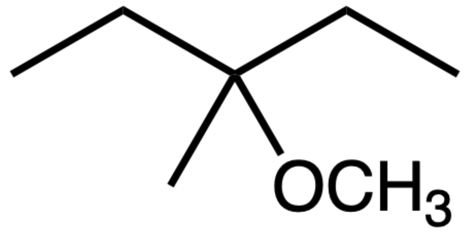

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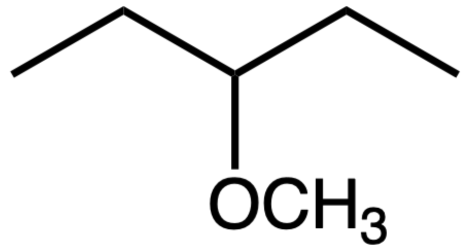

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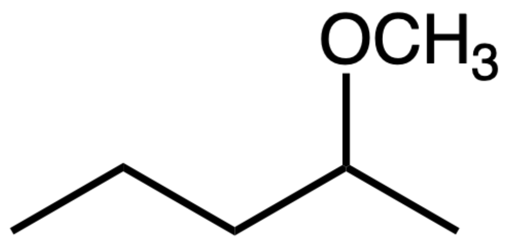

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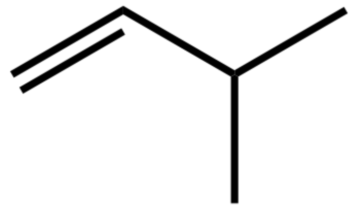

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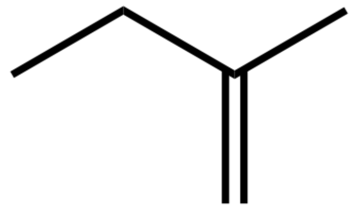

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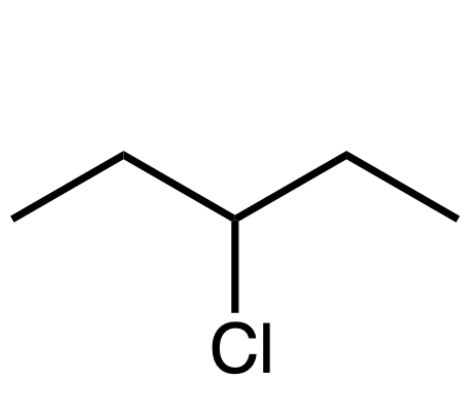
ORGANIC CHEMISTRY: PROBLEM 7.7

Which of the following compound could be mixed with $NaOCH_3$ to make compound **16**?

— answer —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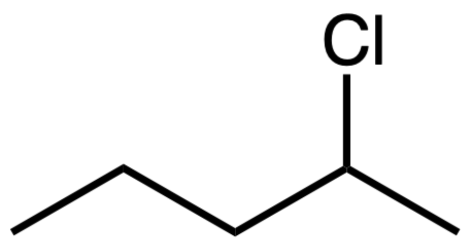
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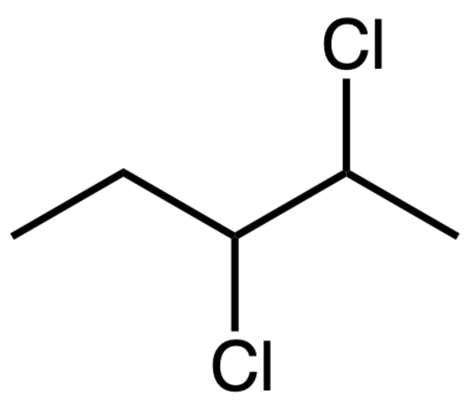
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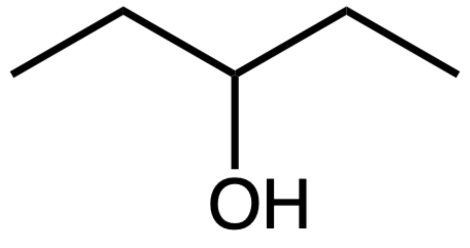
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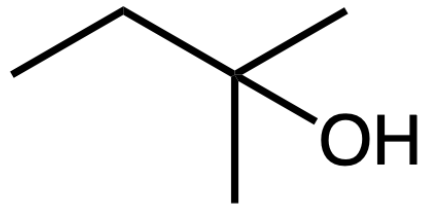
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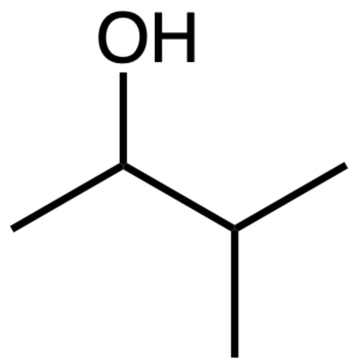
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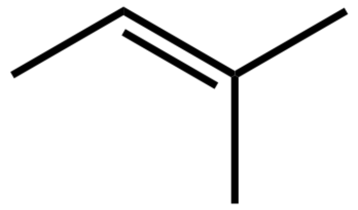
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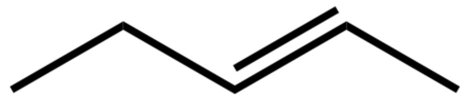
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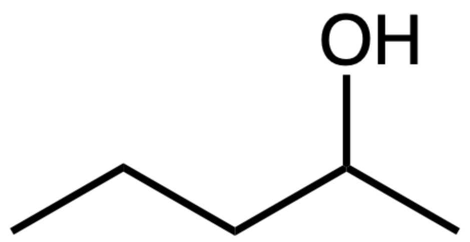
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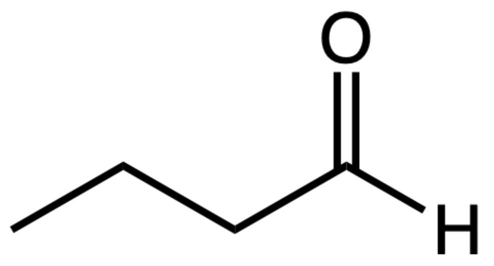
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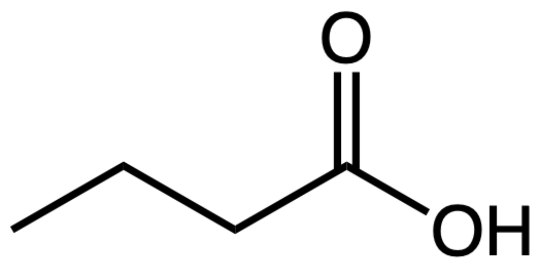
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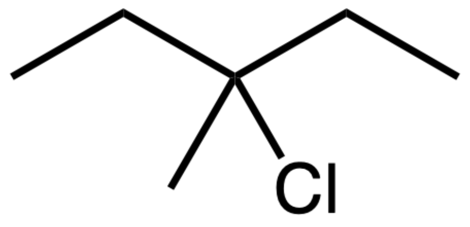
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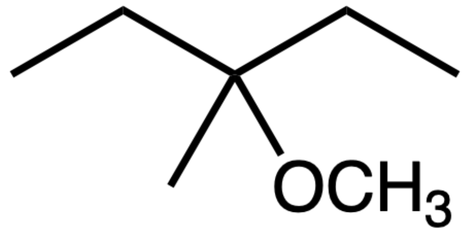
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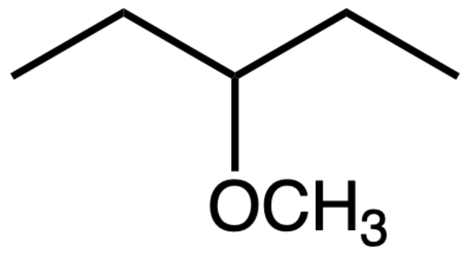
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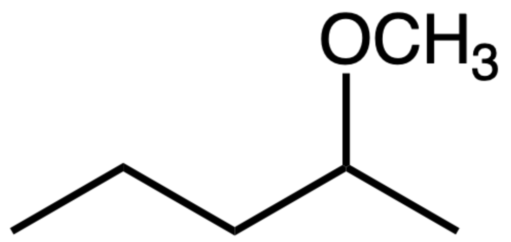
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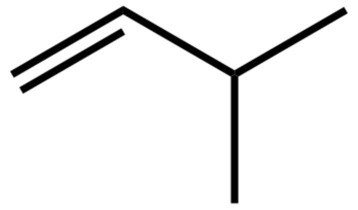
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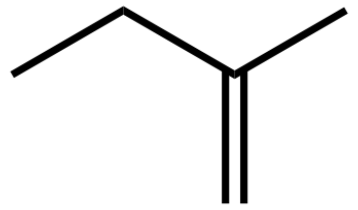
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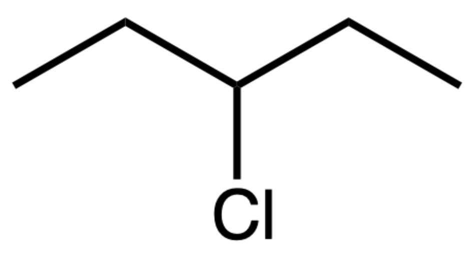
ORGANIC CHEMISTRY: PROBLEM 7.8

Which of the following compounds could exhibit geometric isomerism?

— answer —



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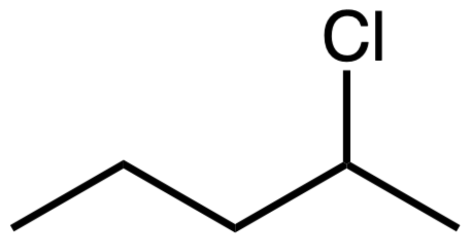

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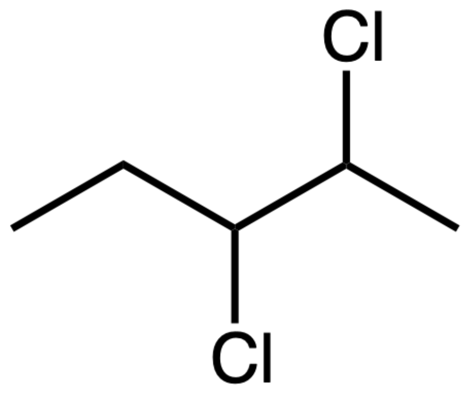

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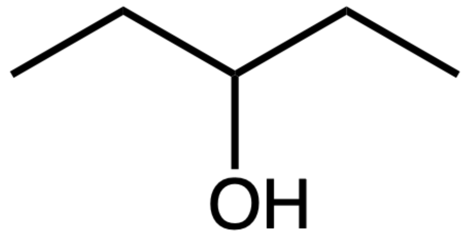

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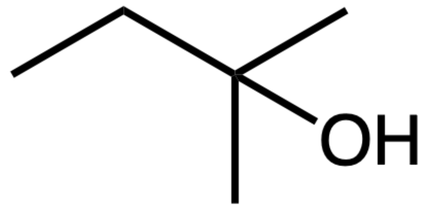

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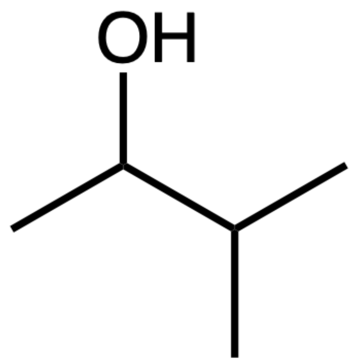

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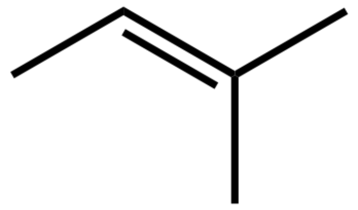

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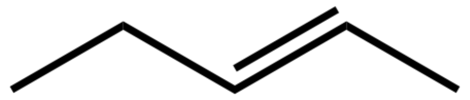

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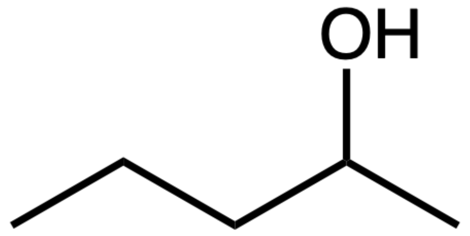

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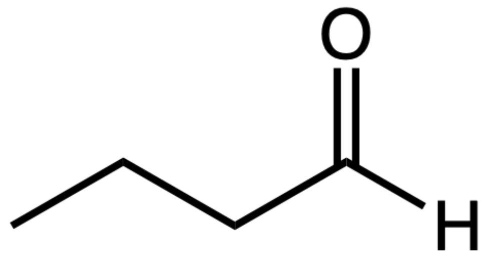

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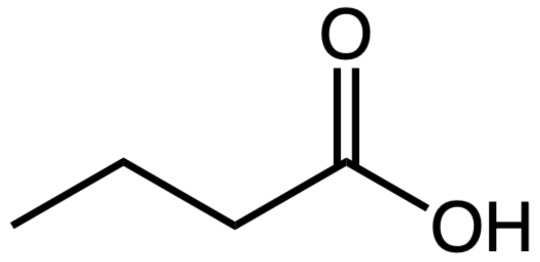

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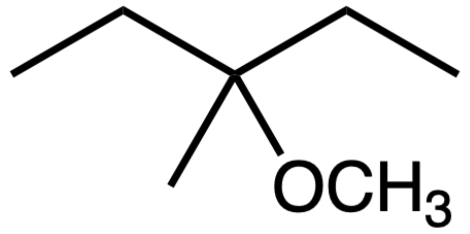

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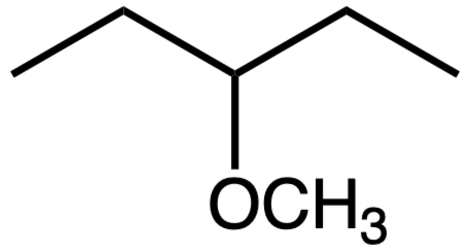

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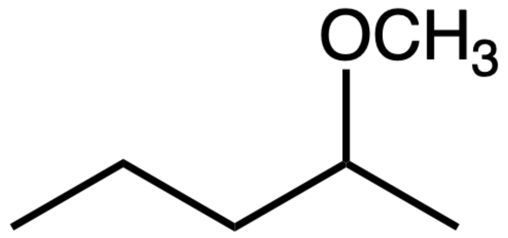

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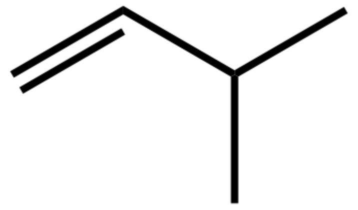

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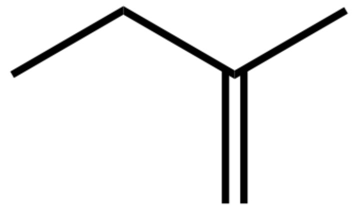

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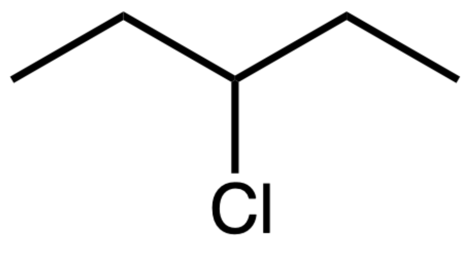
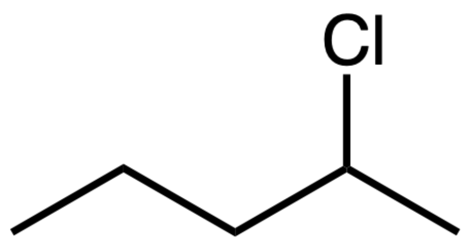
ORGANIC CHEMISTRY: PROBLEM 7.8

Which of the following compounds contains a chiral carbon center?

— answer —



(1)



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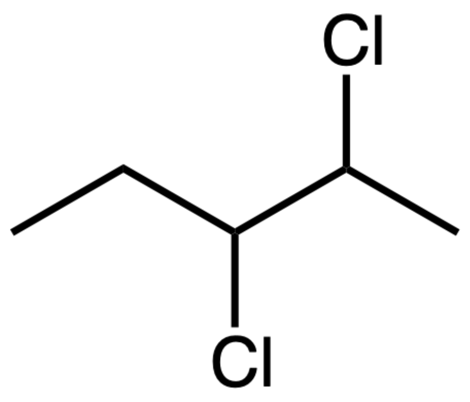

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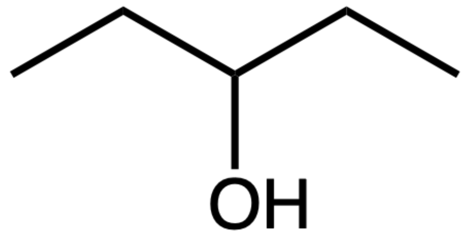

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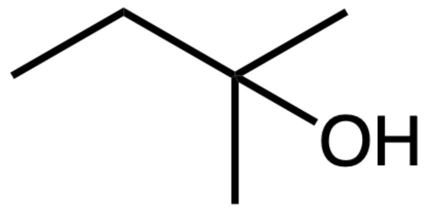

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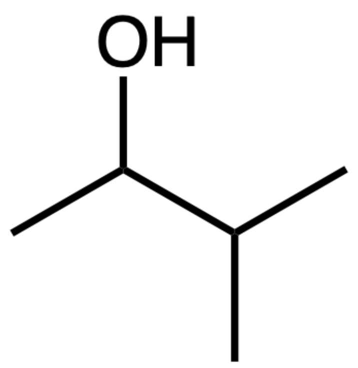

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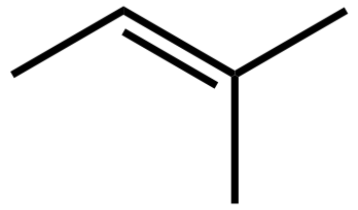

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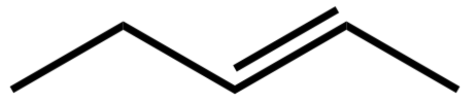

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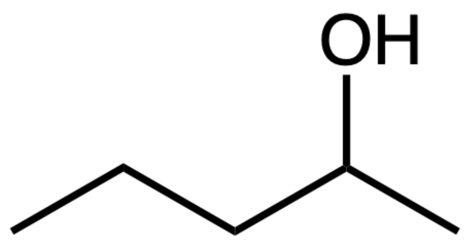

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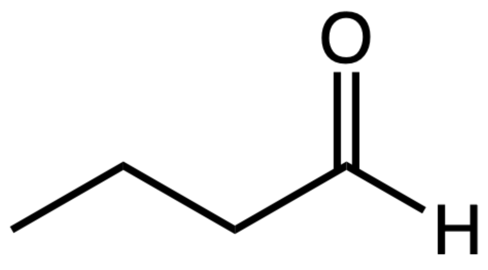

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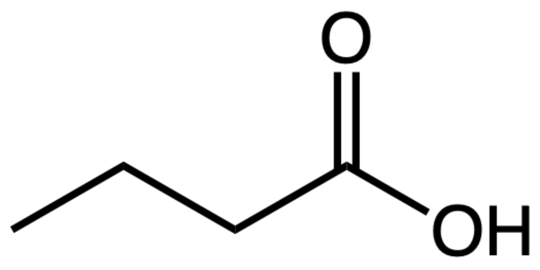

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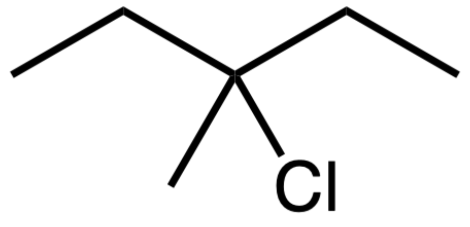

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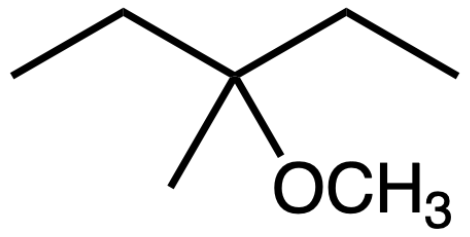

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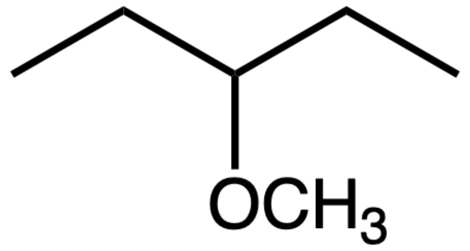

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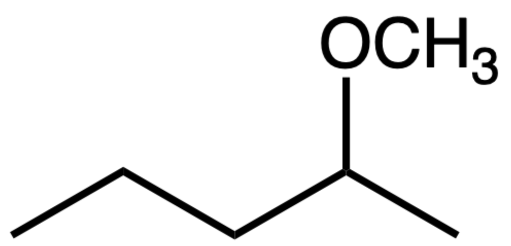

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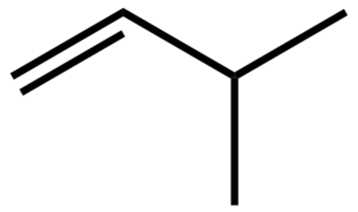

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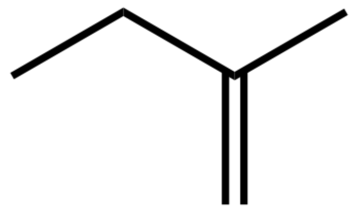
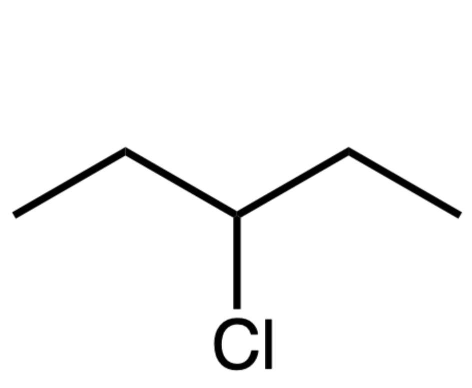


(18)

ORGANIC CHEMISTRY: PROBLEM 7.9

Choose any two compounds that can be mixed together with an acid catalyst to produce an ester via condensation.

— answer —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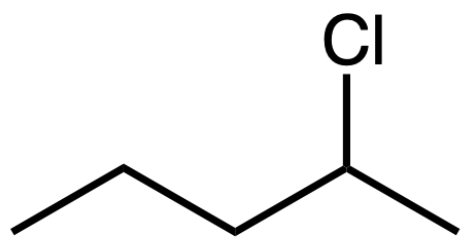
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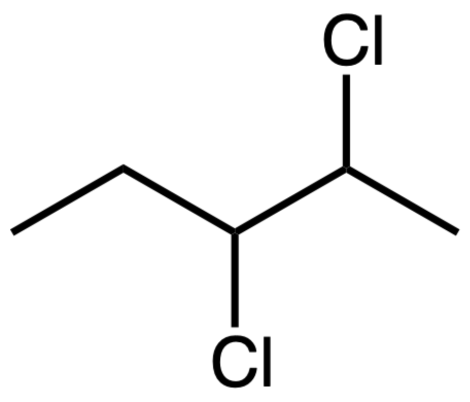
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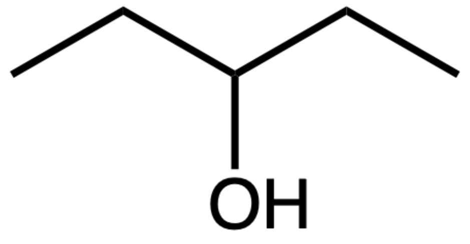
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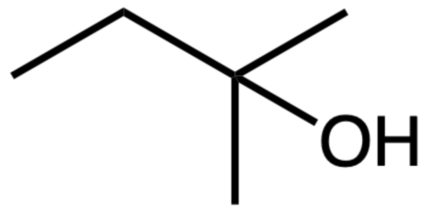
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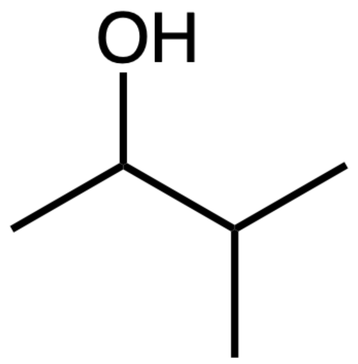
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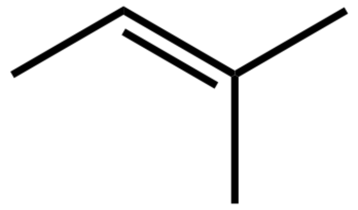
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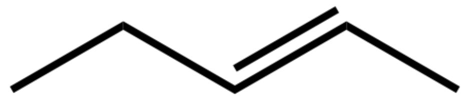
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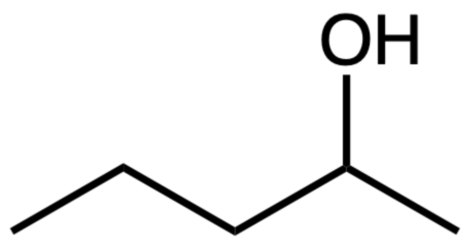
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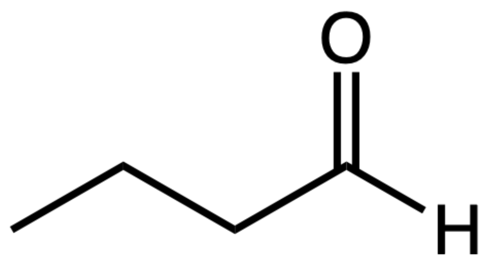
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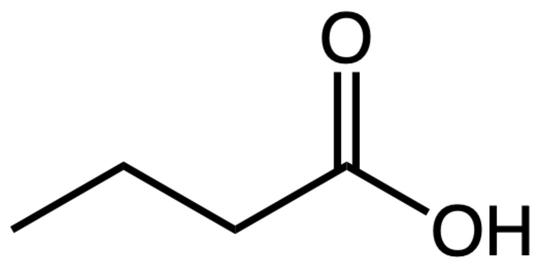
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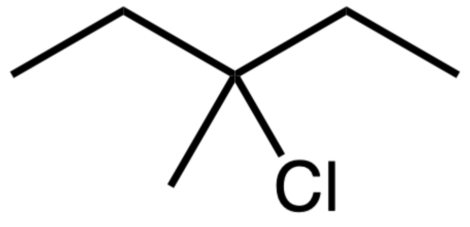
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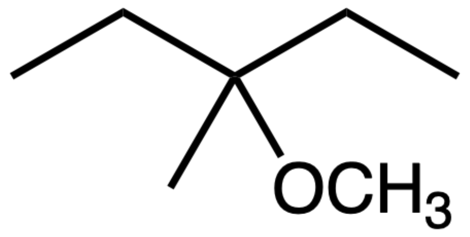
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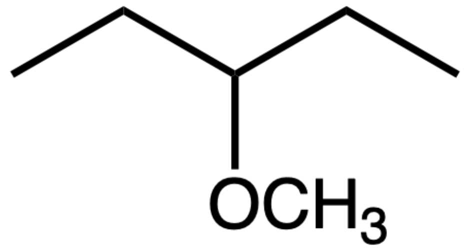
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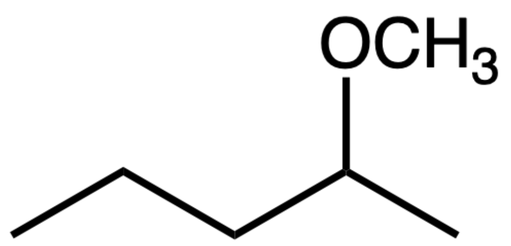
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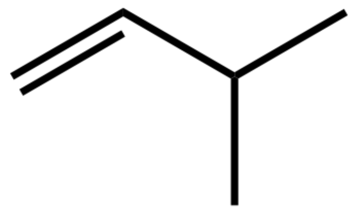
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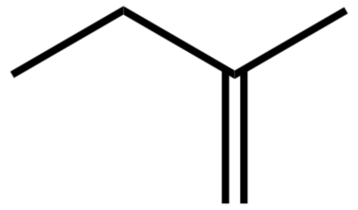
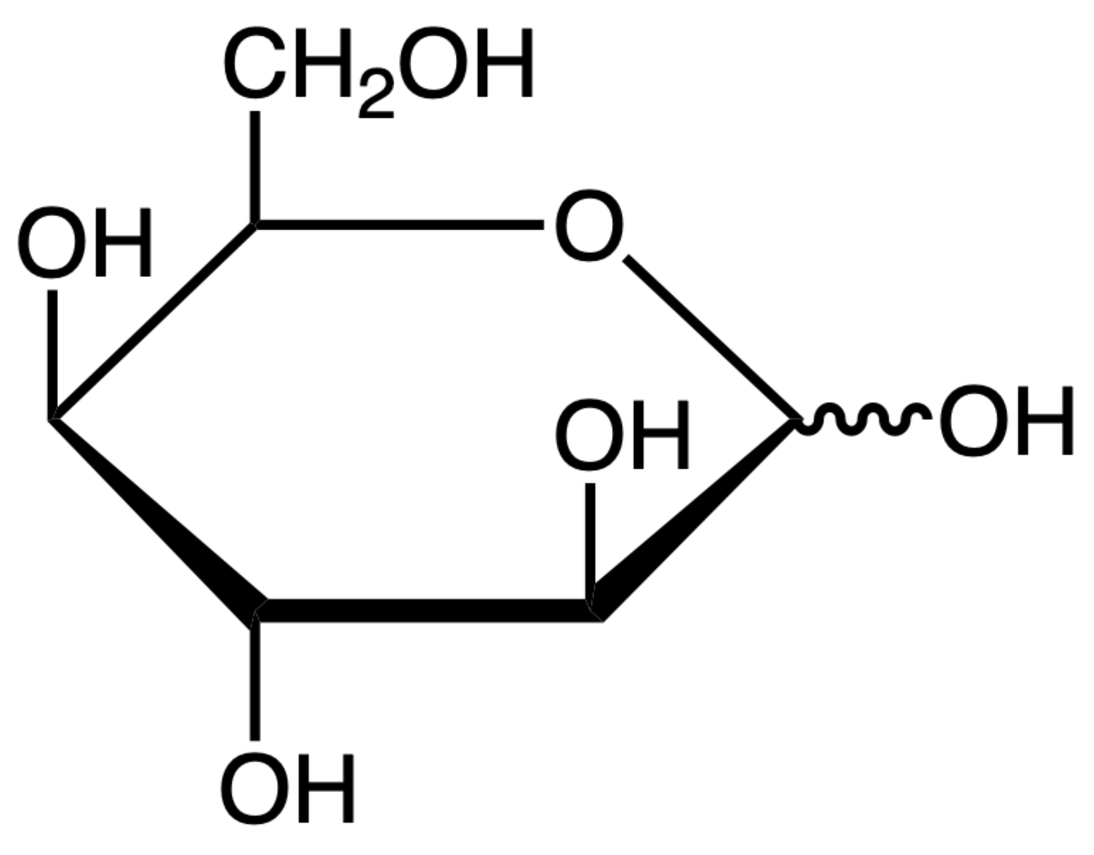

(18)

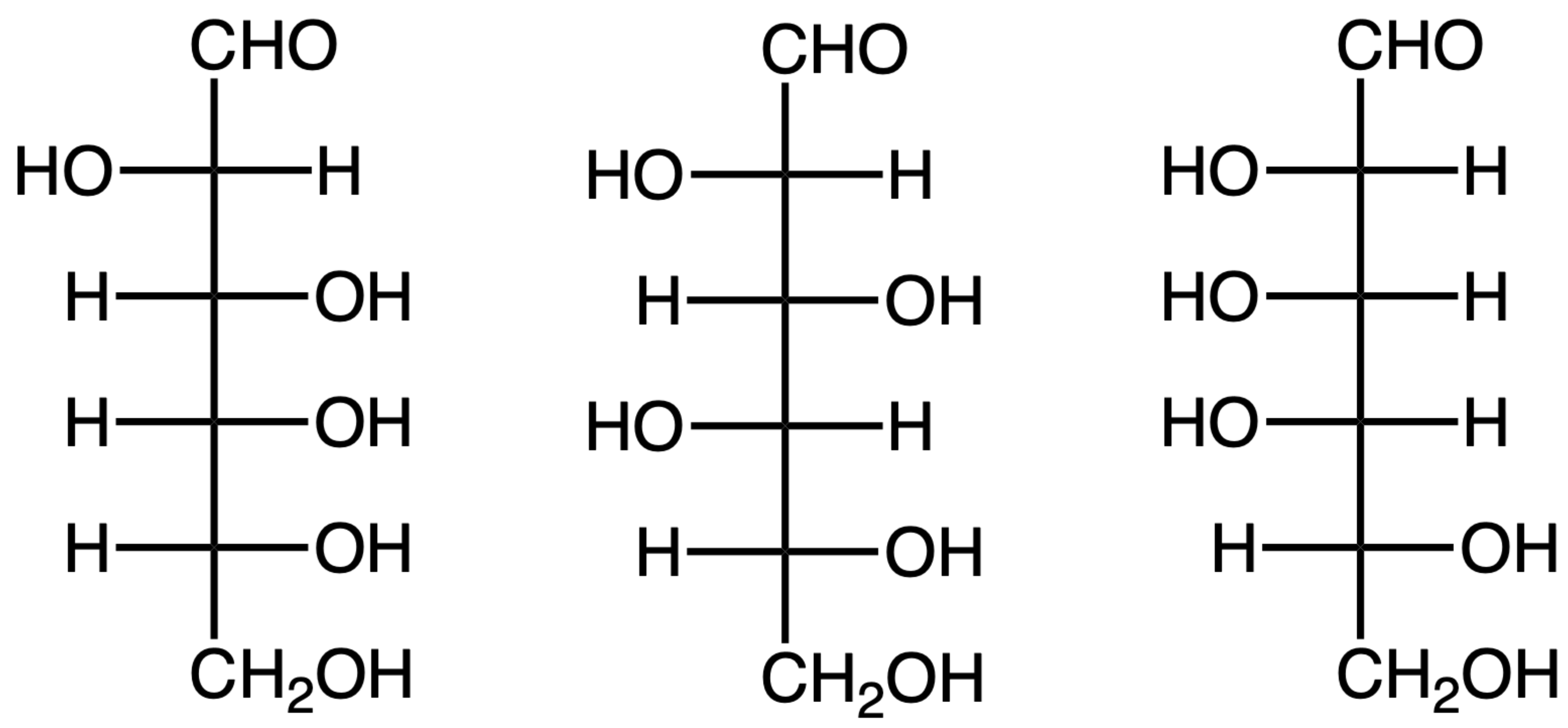
BIOCHEMISTRY: PROBLEM 8.1

The Haworth projection for the D-Idose pyranose is shown below. Which is the correct Fischer projection for D-Idose?

— answer —



D-Idose

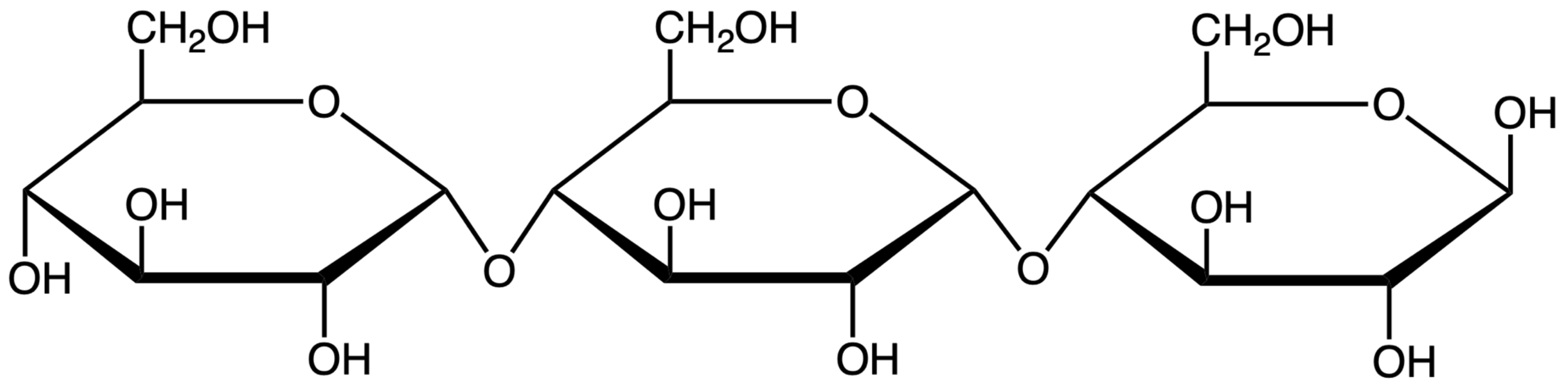


(A) (B) (C)

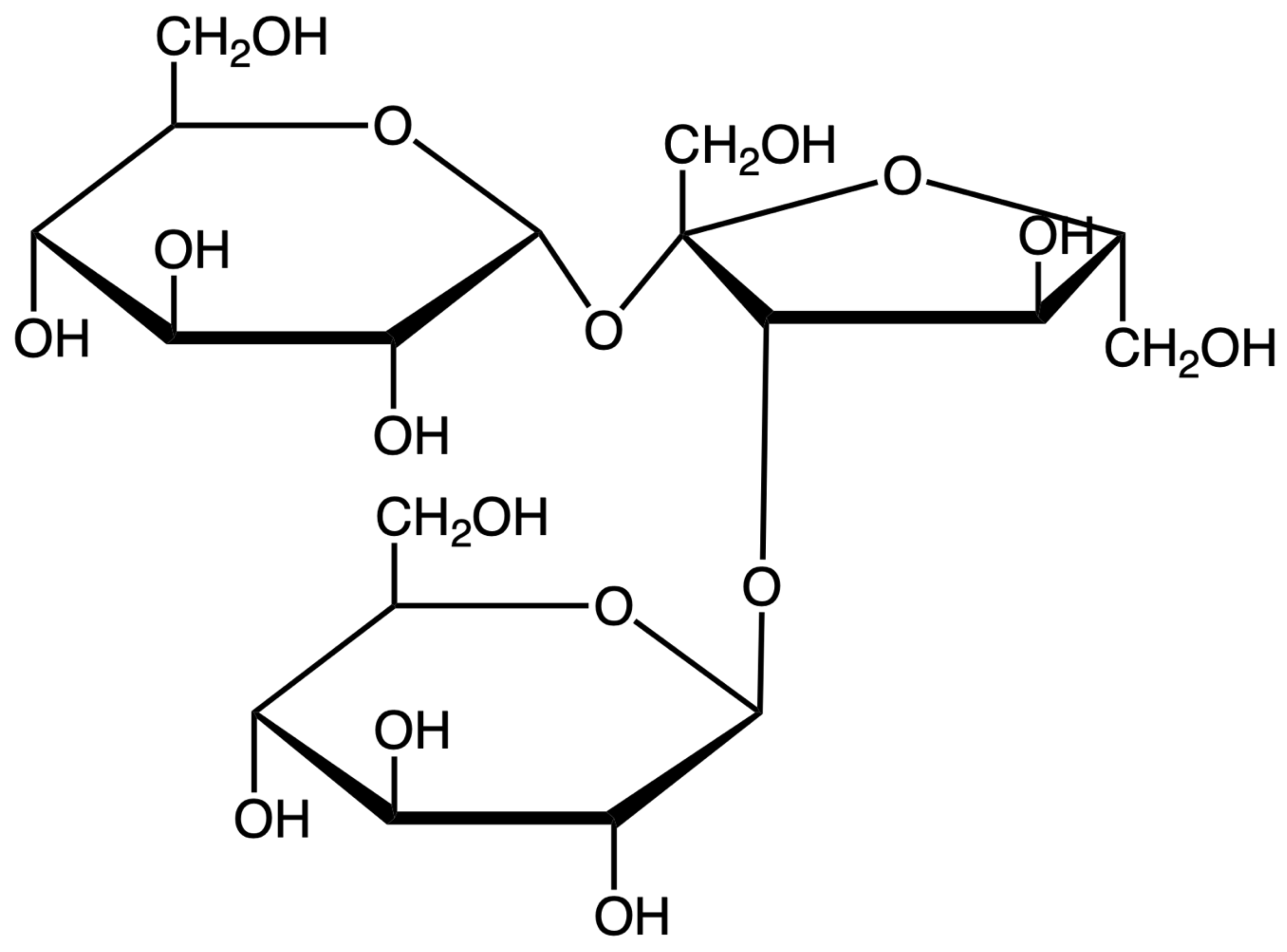
BIOCHEMISTRY: PROBLEM 8.2

The trisaccharaides maltotriose, melezitose, and kestose are shown below. Which is a reducing sugar?

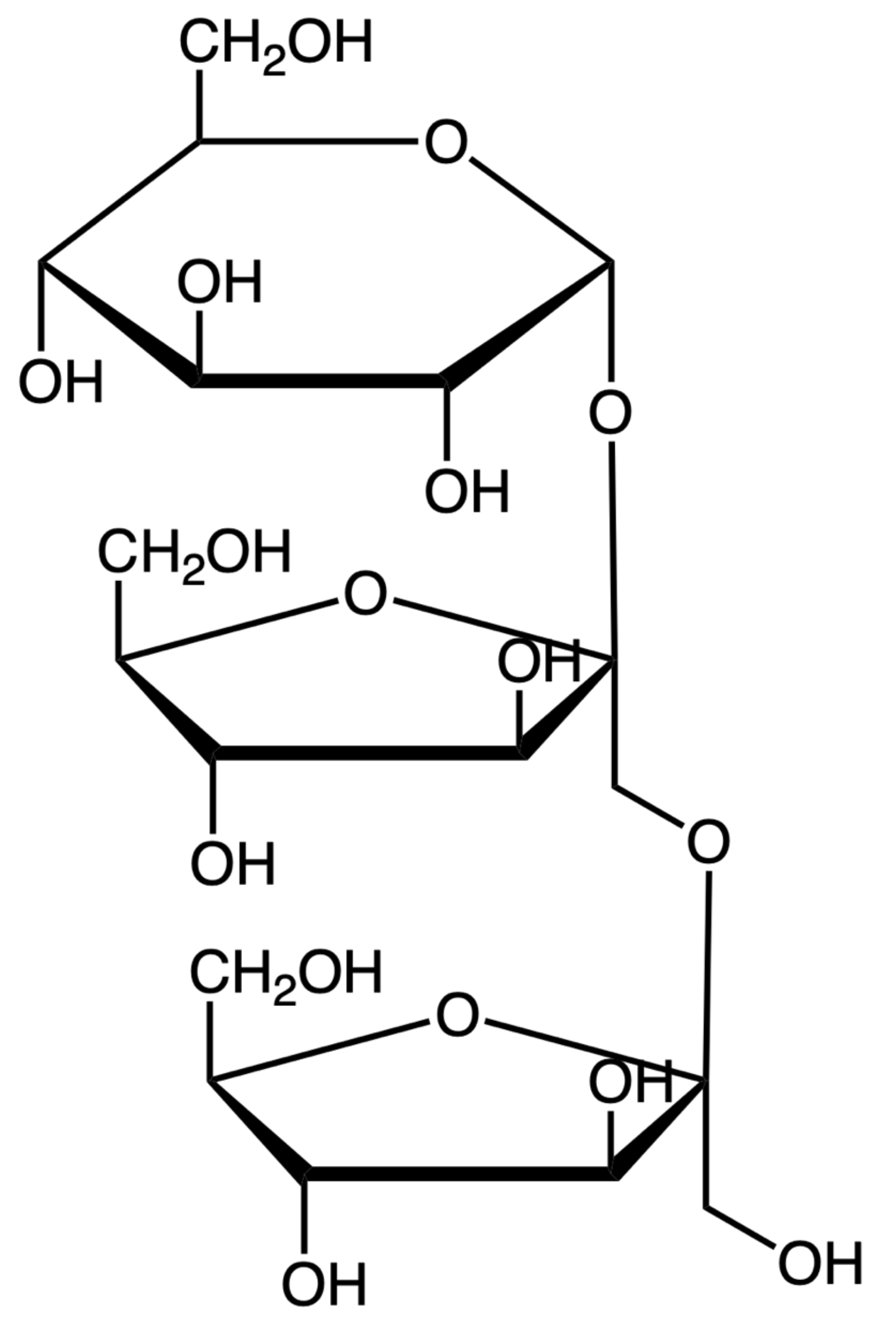
— answer —



Maltotriose



Melezitose

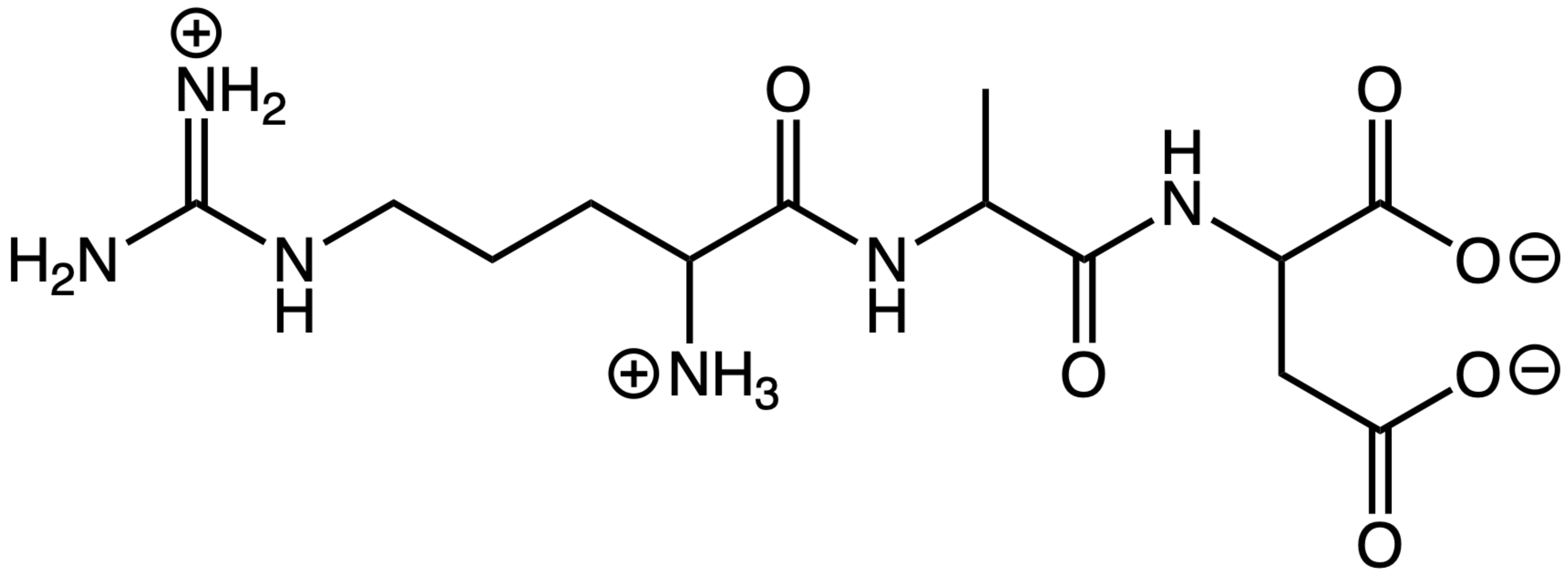


Kestose

BIOCHEMISTRY: PROBLEM 8.3

The tripeptide shown below is comprised of three amino acids. Which amino acid would travel the farthest toward the positive electrode during electrophoresis with a pH = 6 buffer.

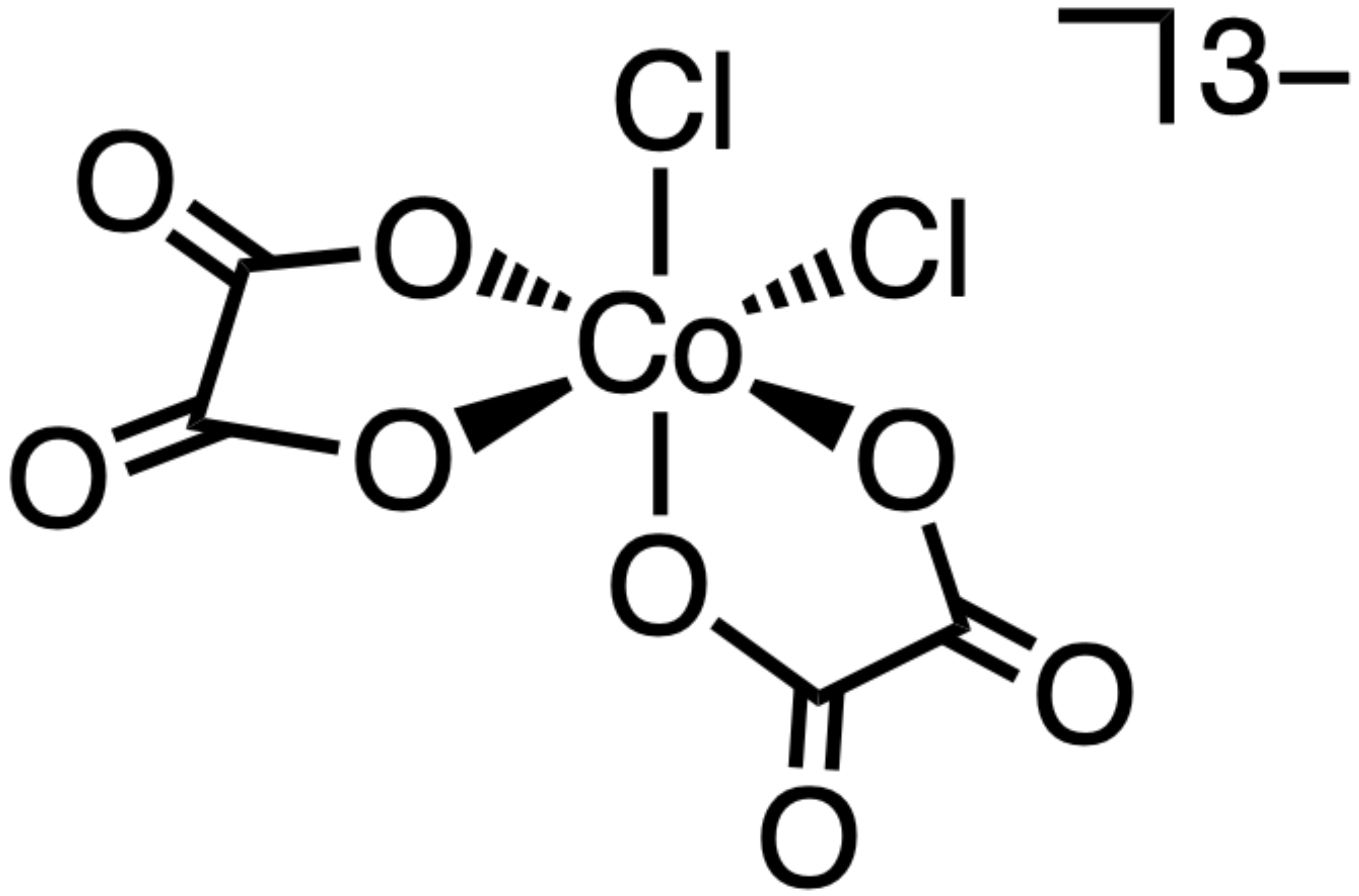
— answer —



TRANSITION METALS: PROBLEM 9.1

Dichlorobisoxalatocobaltate(III) can exist as three optical isomer. One is drawn below. Draw the other two stereoisomers.

— answer —



TRANSITION METALS: PROBLEM 9.2

You have three colored solutions: (1) violet, (2) yellow, and (3) green. Match each of the colored solutions (1–3) to the corresponding complex ions: (a) $[Cr(NH_3)_6]^{3+}$, (b) $[Cr(H_2O)_6]^{3+}$, and (c) $[Cr(H_2O)_4Cl_2]^{+}$.

Spectrochemical series: $CN^- > NO_2^- > CN^- >$ en $> NH_3 > H_2O > F^- > Cl^- > Br^- > I^-$

— answer —

TRANSITION METALS: PROBLEM 9.3

For each pair of complex ions, determine: (a) the number of 3*d* electrons and oxidation state, (b) if each is high- or low-spin, (c) if each is paramagnetic or diamagnetic, and (d) the magnetic moment (μ_{eff}).

Spectrochemical series: CN^- > NO_2^- > CN^- > en > NH_3 > H_2O > F^- > Cl^- > Br^- > I^-

– answer –

	Complex ions	No. 3d electrons?	Spin?	Magnetism?	μ_{eff} (B.M.)
(i)	$[Fe(H_2O)_6]Cl_3$				
	$Na_3[Fe(CN)_6]$				
(ii)	$[Co(NH_3)_6]Cl_3$				
	$K_3[CoF_6]$				