FINAL EXAM

PRACTICE PROBLEMS

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CHEMISTRY 165B // SPRING 2020

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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 —

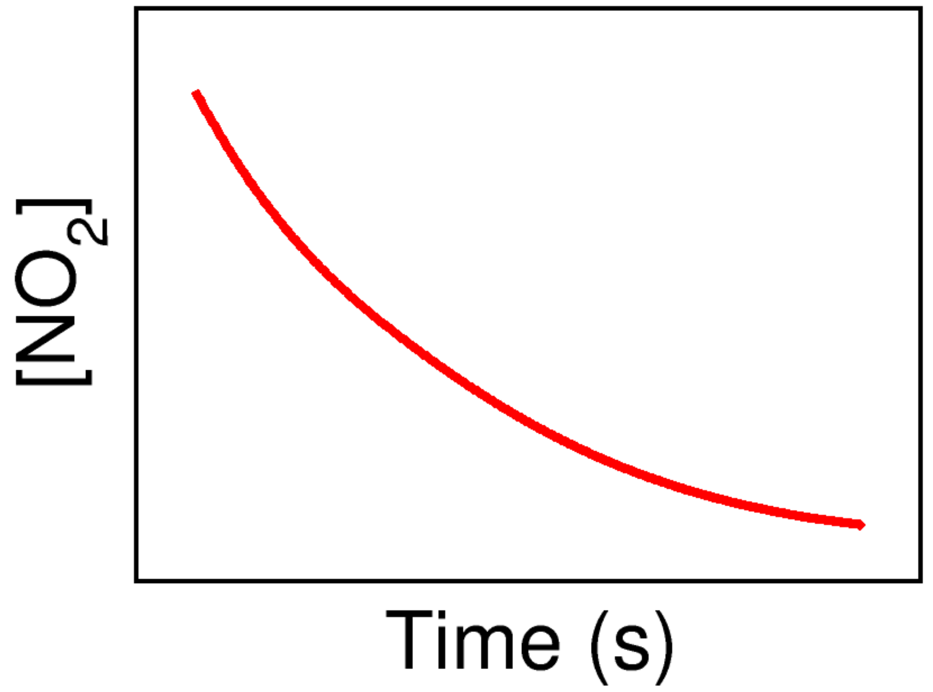
KINETICS: PROBLEM 1.3

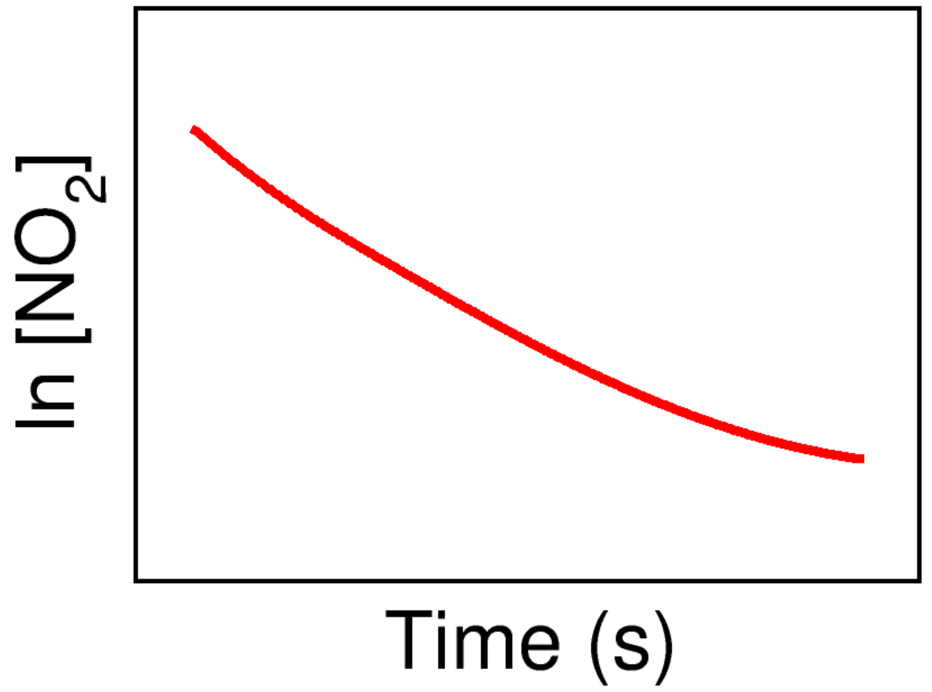
The following concentration-time data are plotted below for the decomposition of nitrogen dioxide gas at 298 K.

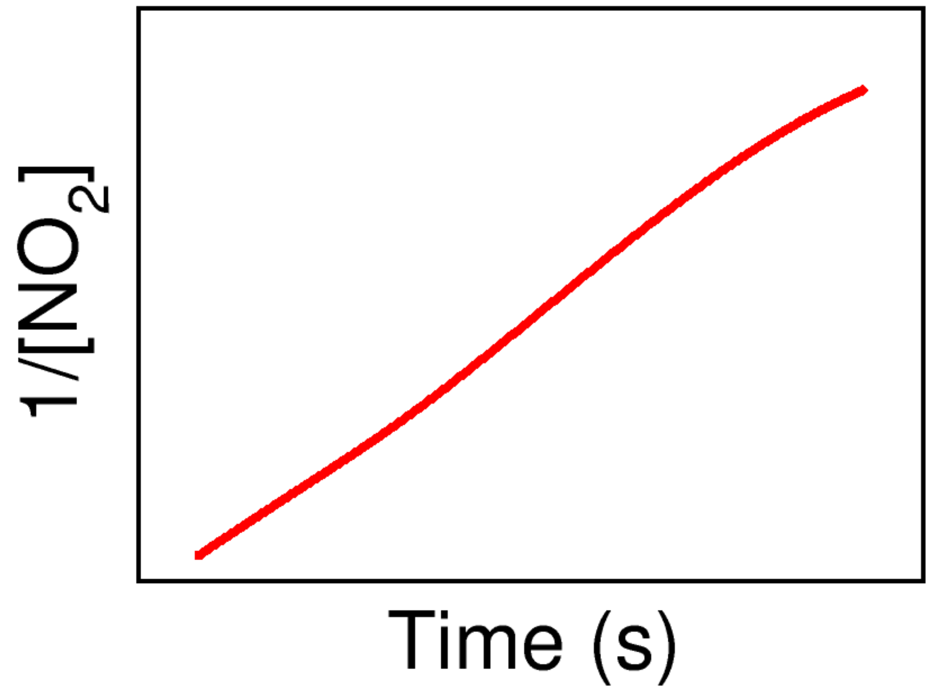
$$2\ NO_2\ (g) \rightarrow 2\ NO\ (g) + O_2\ (g)$$

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 (ΔG^o_{rxn}) at 25 ° C.

	$CaSO_4{\cdot}2H_2O$ (s)	$CaSO_4$ (s)	H_2O (g)
$\Delta G^o_f\ \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−1797.4	−1322.0	−228.6
$\Delta H^o_f\ \left(\frac{\mathrm{kJ}}{\mathrm{mol}}\right)$	−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 ΔG^o_{rxn}:

THERMODYNAMICS: PROBLEM 4.2

Consider the following decomposition reaction:

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

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
$S^\circ \left(\frac{\mathrm{J}}{\mathrm{mol} \cdot \mathrm{K}}\right)$	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.

— answer —

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

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 amu = 1.6605×10^{-27} kg   c = 3.00×10^{8} m/s $1\ \mathrm{J} = 1\ \mathrm{kg} \cdot \mathrm{m}^2/\mathrm{s}^2$

— answer —

NUCLEAR CHEMISTRY: PROBLEM 6.3

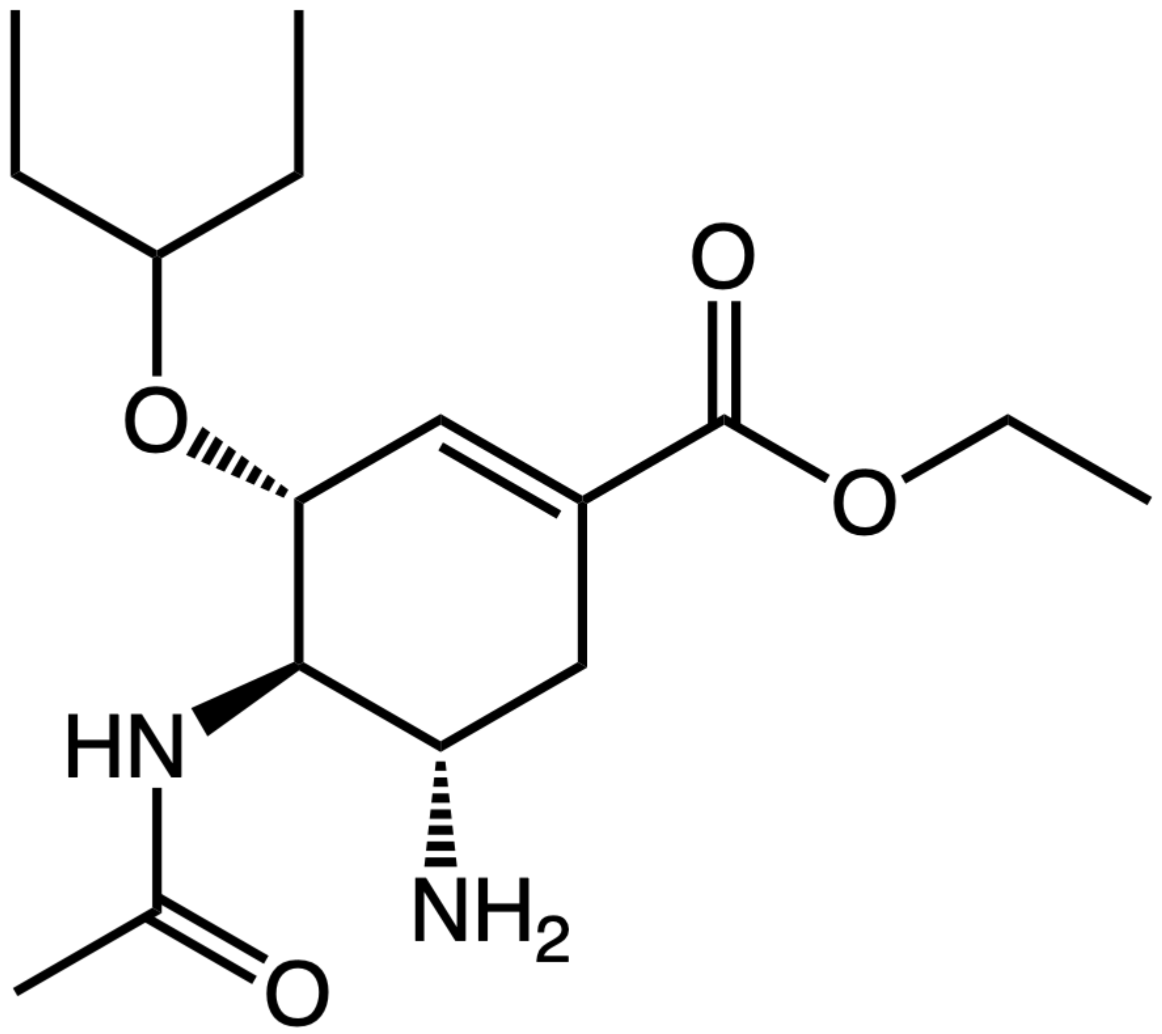
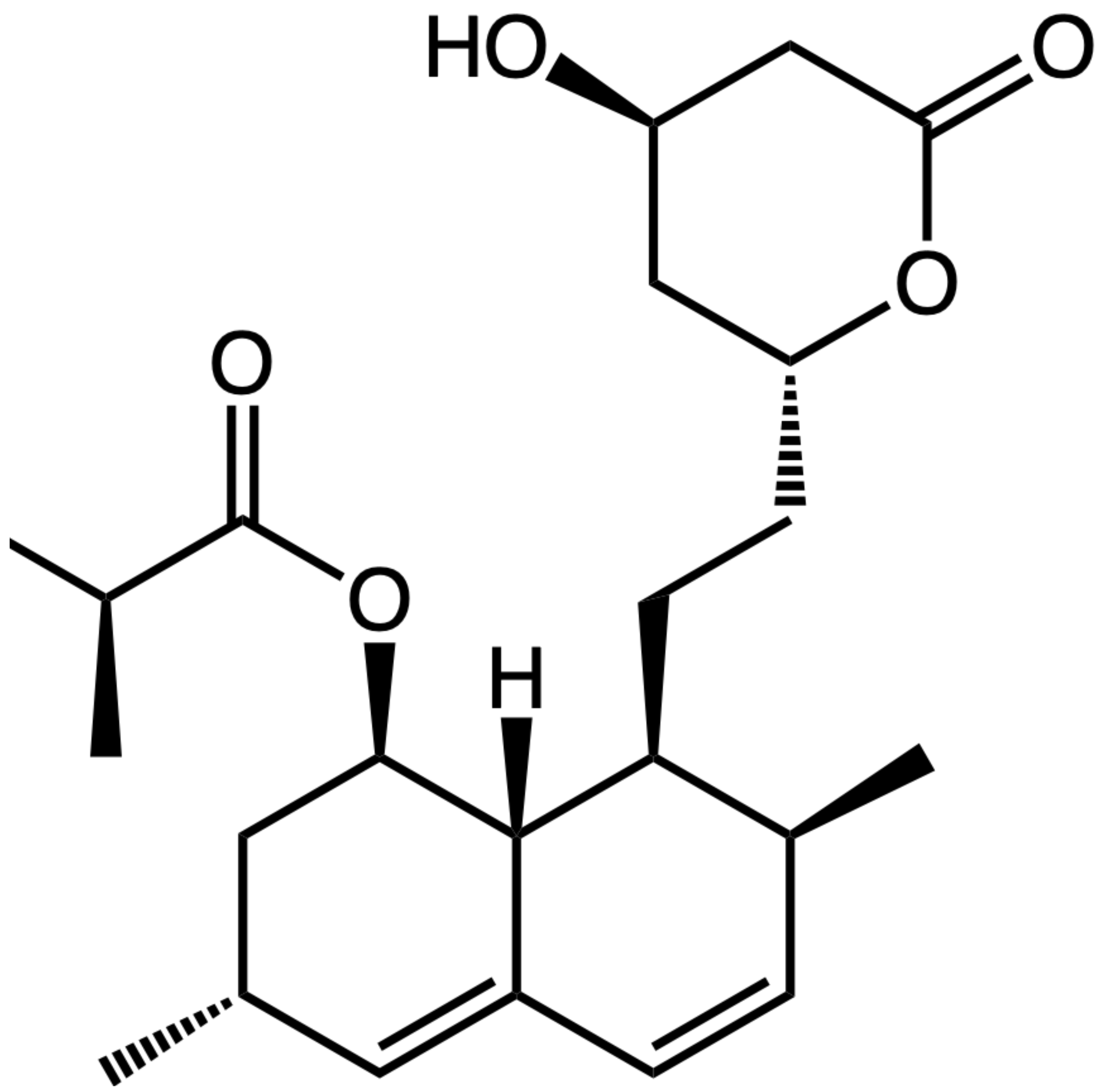
A piece of paper from an ancient scroll undergoes ^{14}C-decay with a rate of 9.07 decays/min. A fresh piece of paper also undergoes ^{14}C-decay but with a rate of 13.6 decays/min. If the half-life for ^{14}C-decay is 5730 years, how old is the scroll?

— answer —

ORGANIC CHEMISTRY: PROBLEM 7.1

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

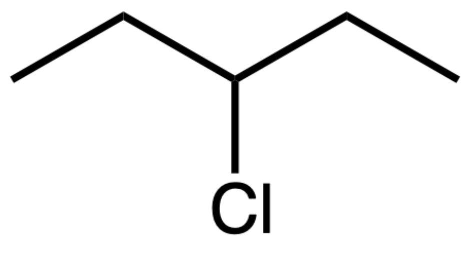
— answer —

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

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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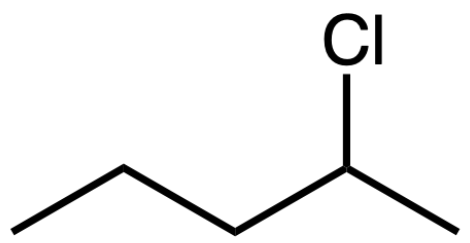

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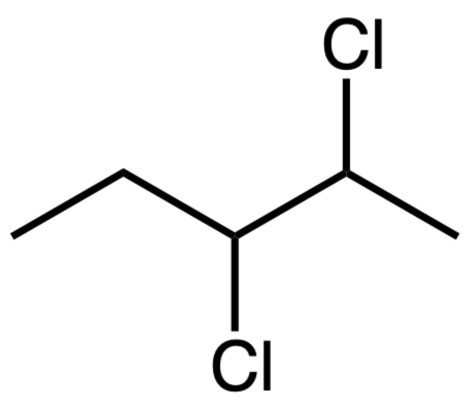

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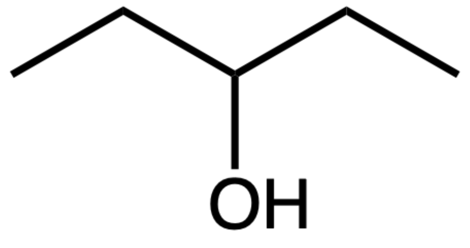

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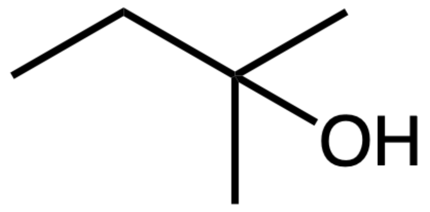

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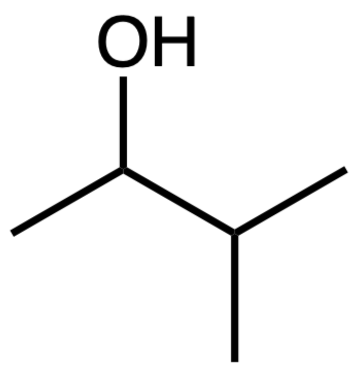

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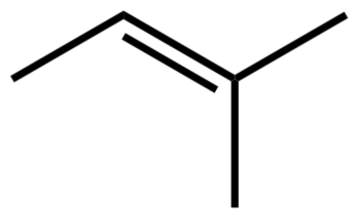

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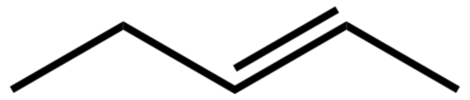

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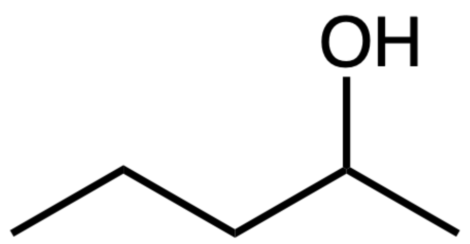

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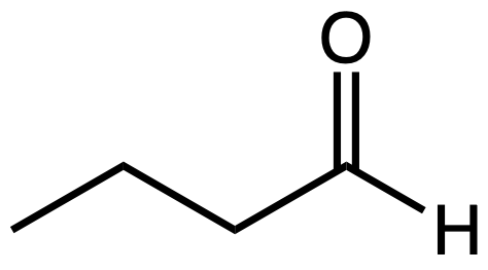

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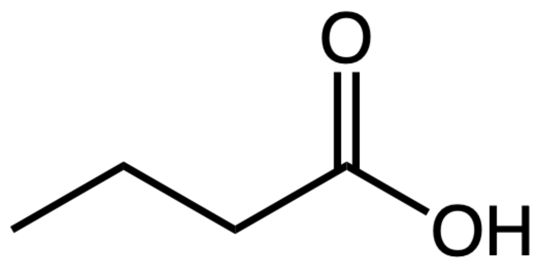

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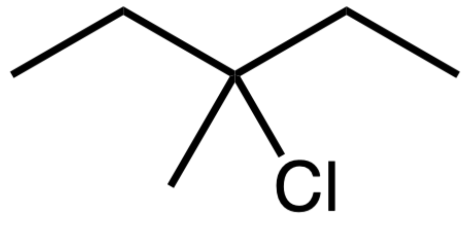

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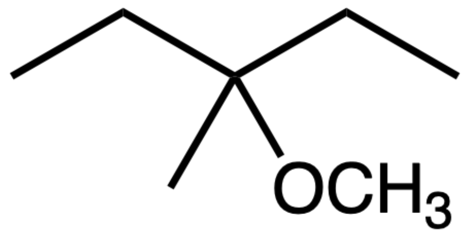

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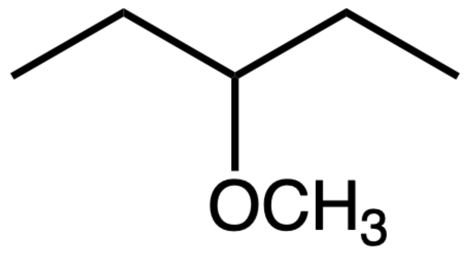

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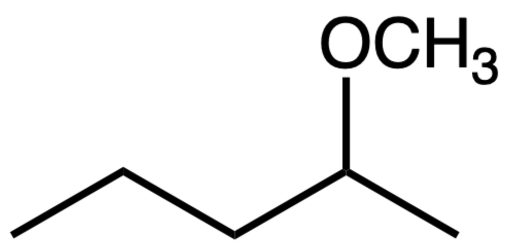

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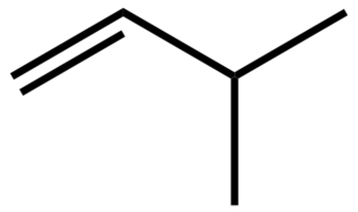

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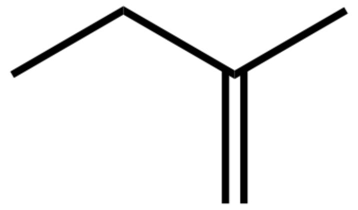

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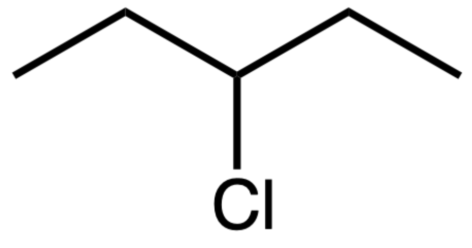
ORGANIC CHEMISTRY: PROBLEM 7.3

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

— answer —



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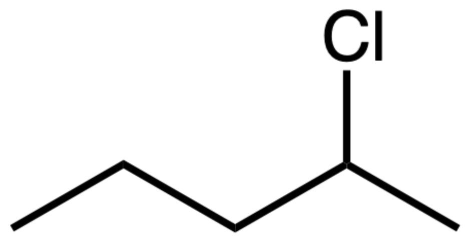

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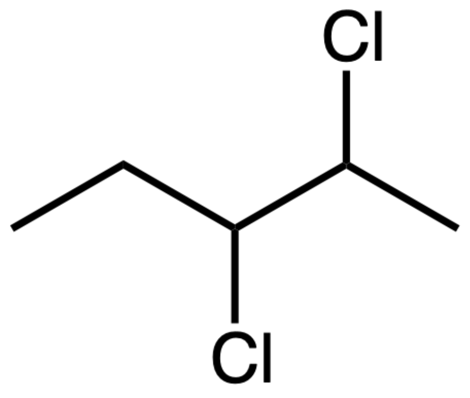

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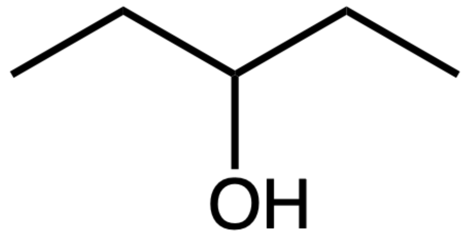

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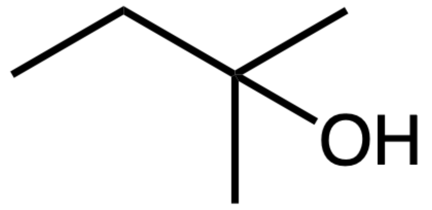

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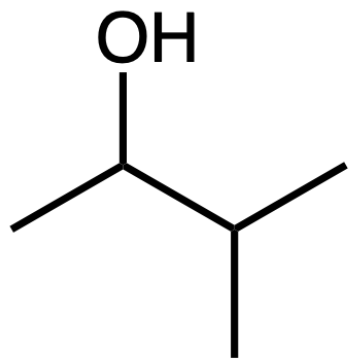

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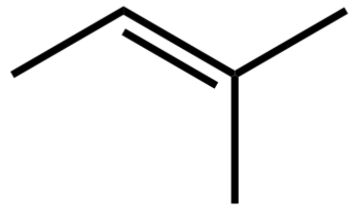

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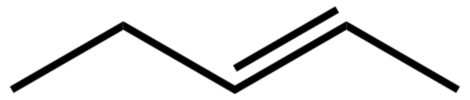

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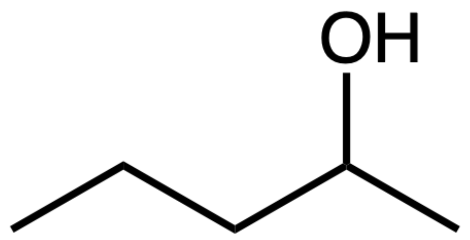

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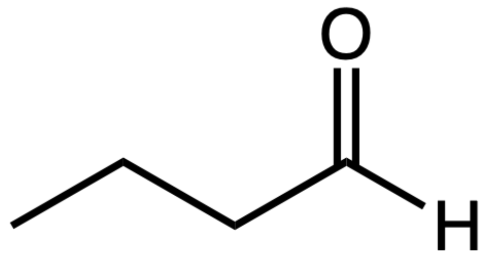

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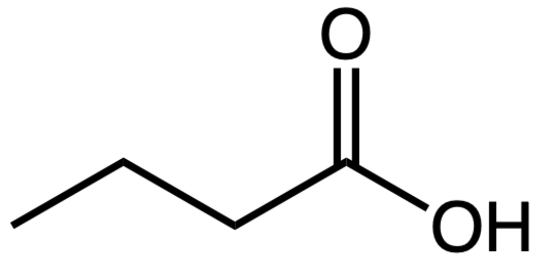

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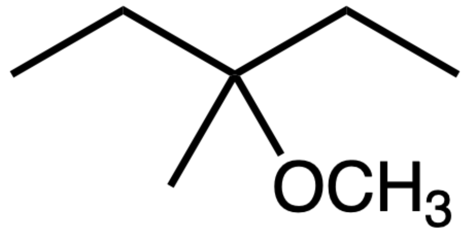

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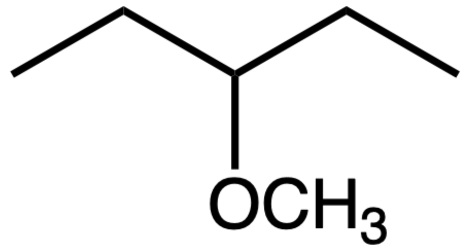

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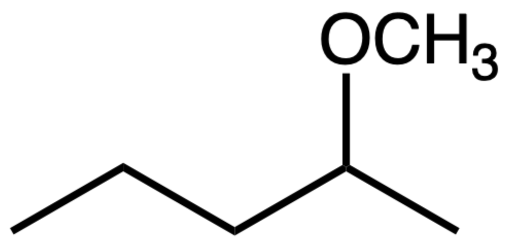

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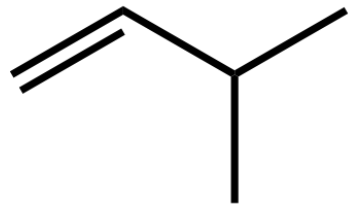

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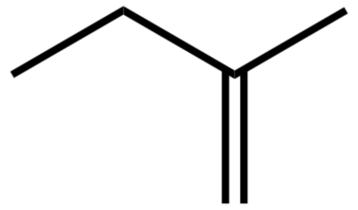

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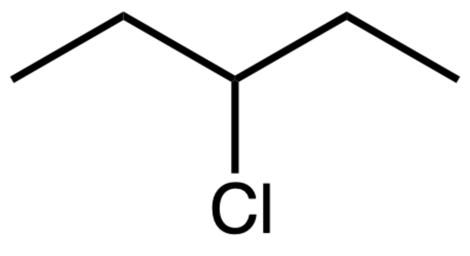
ORGANIC CHEMISTRY: PROBLEM 7.4

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

— answer —



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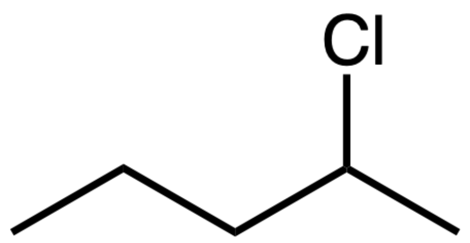

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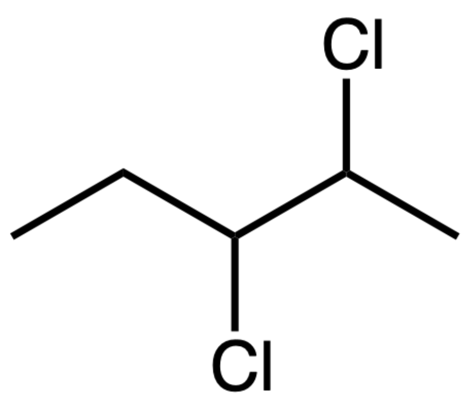

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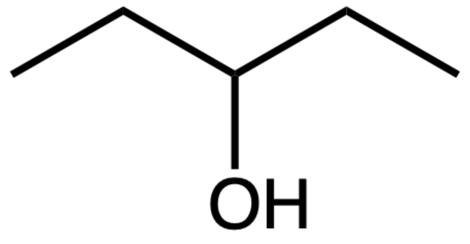

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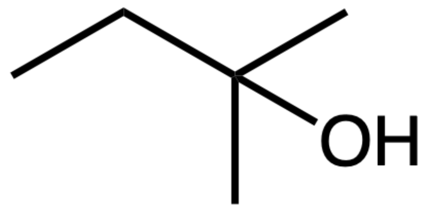

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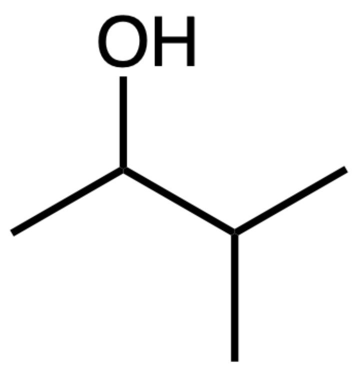

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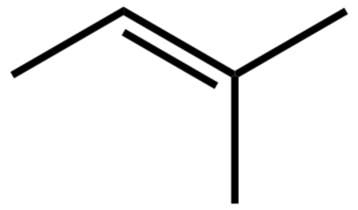

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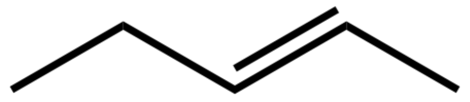

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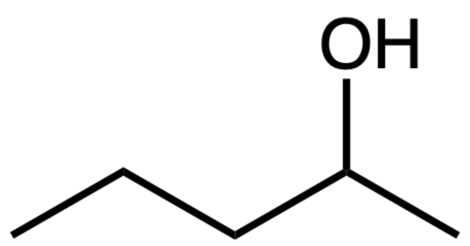

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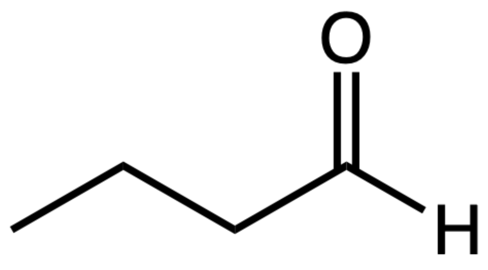

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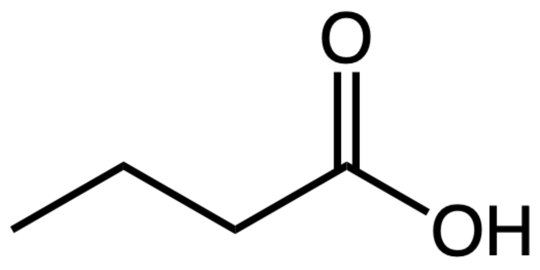

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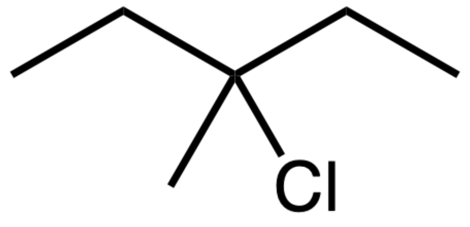

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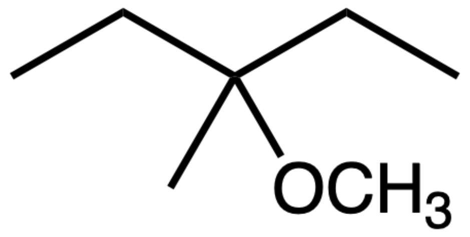

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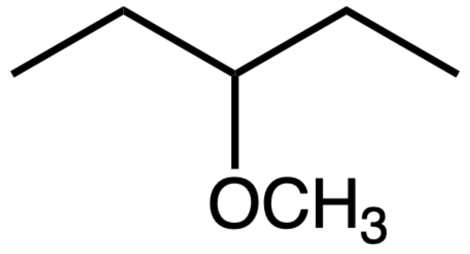

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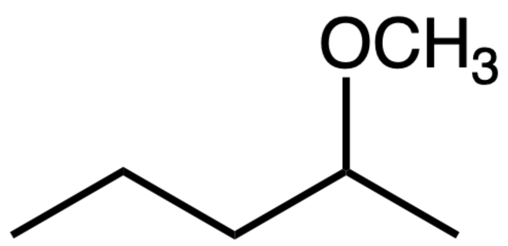

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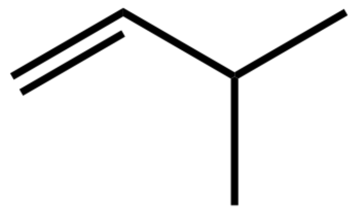

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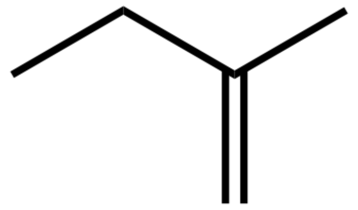

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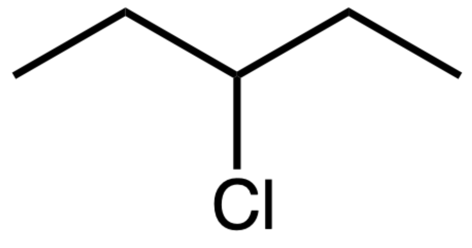
ORGANIC CHEMISTRY: PROBLEM 7.5

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

— answer —



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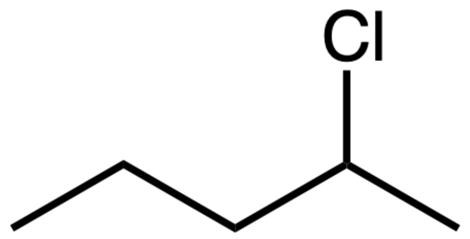

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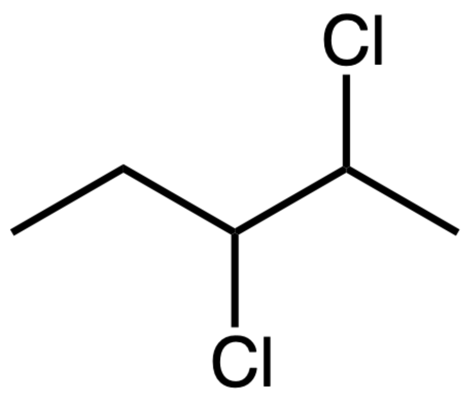

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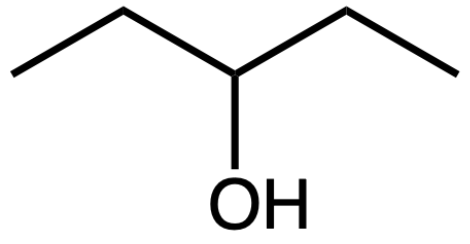

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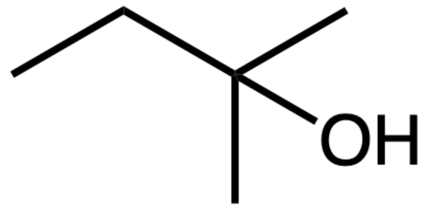

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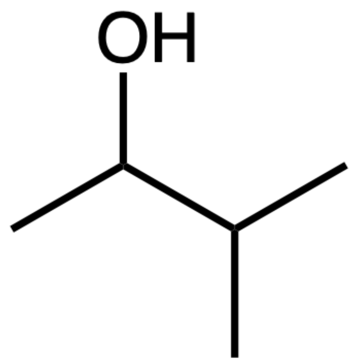

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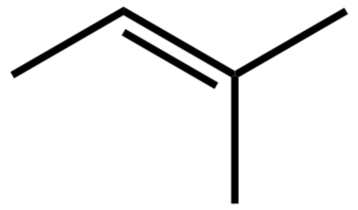

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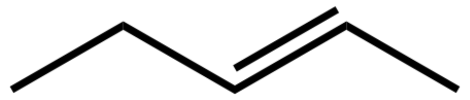

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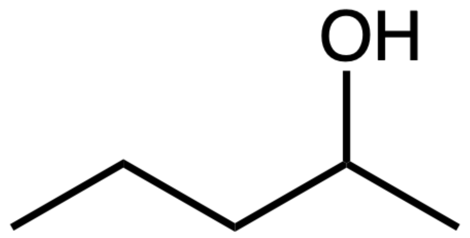

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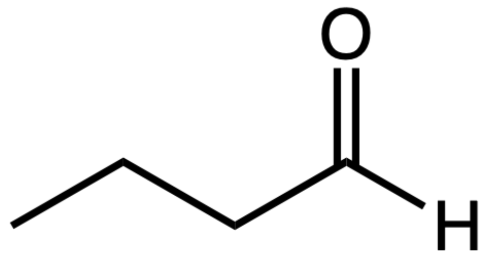

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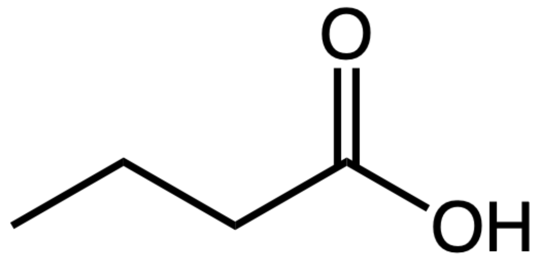

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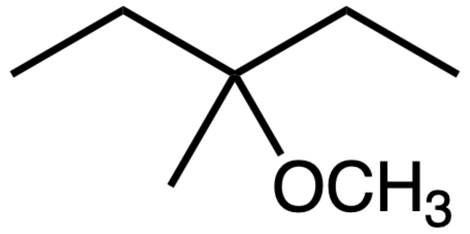

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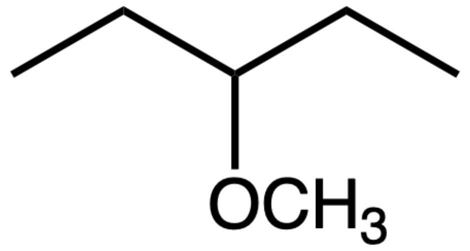

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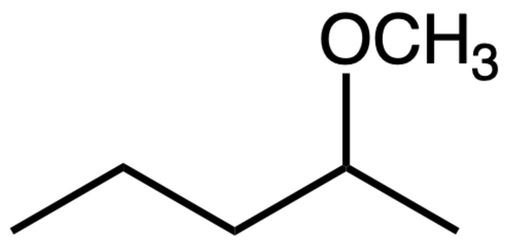

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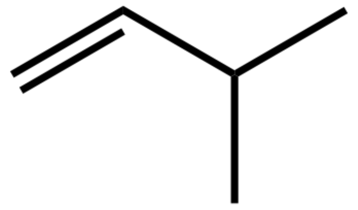

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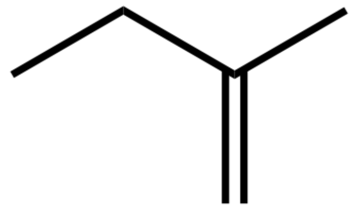

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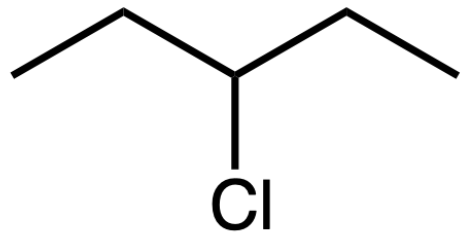
ORGANIC CHEMISTRY: PROBLEM 7.6

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

— answer —



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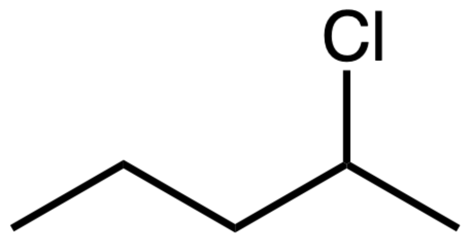

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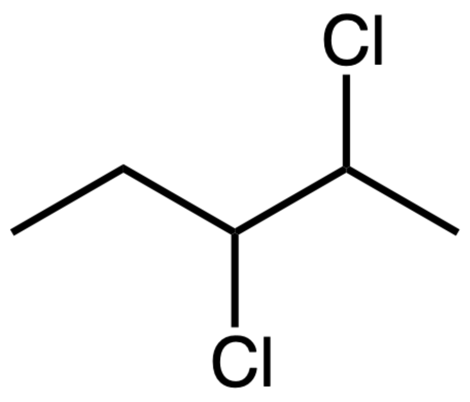

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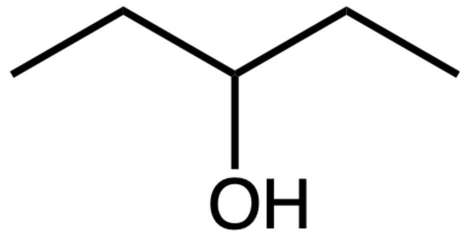

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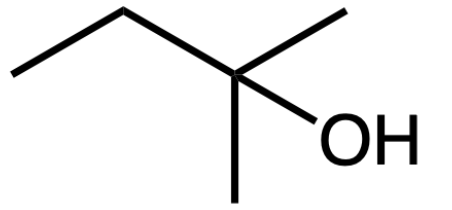

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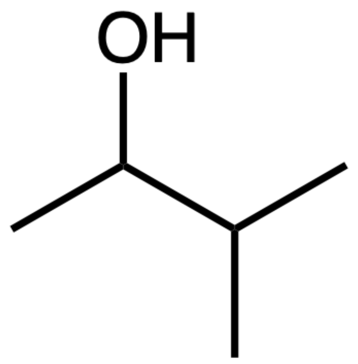

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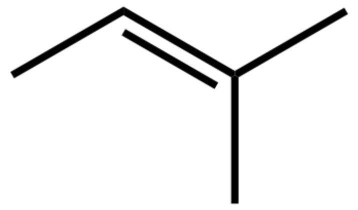
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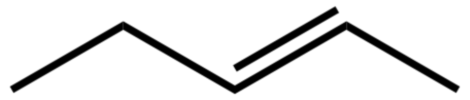
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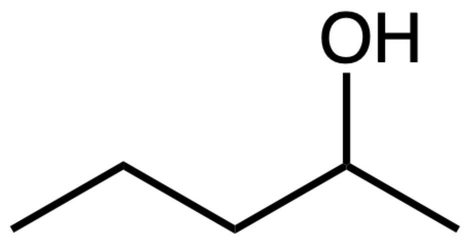

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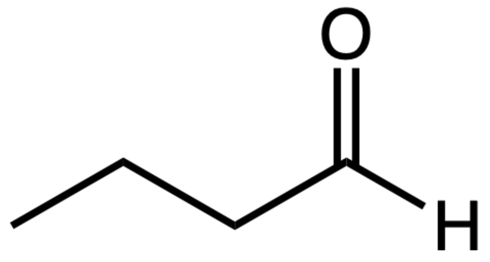

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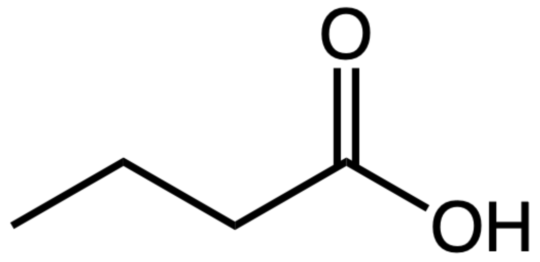

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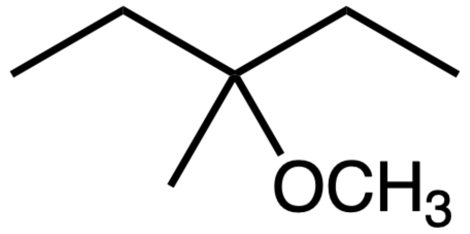

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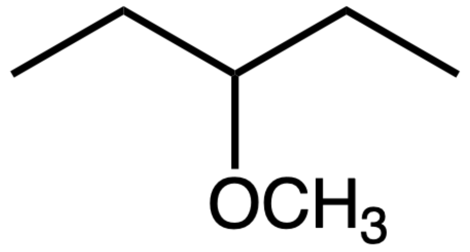

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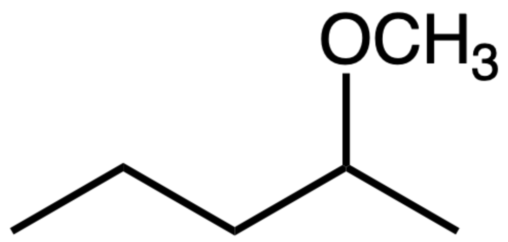

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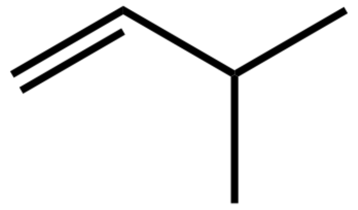
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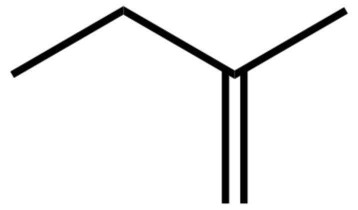
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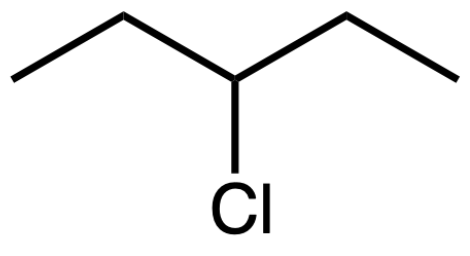
ORGANIC CHEMISTRY: PROBLEM 7.7

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

— answer —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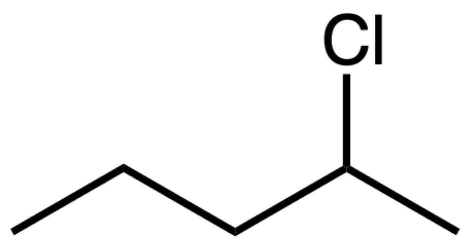
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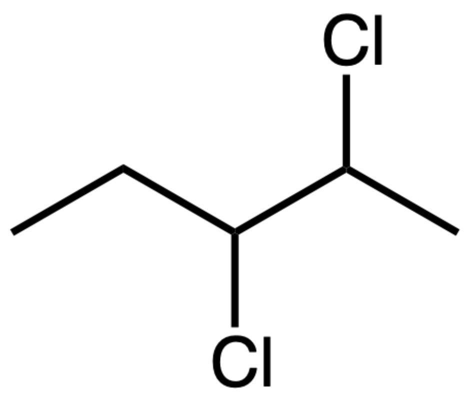
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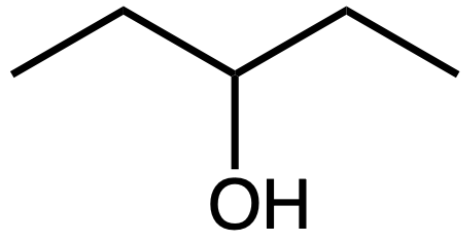
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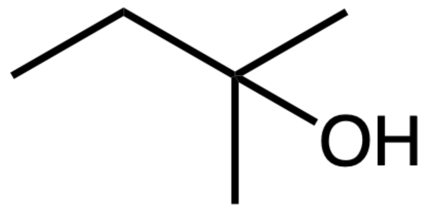
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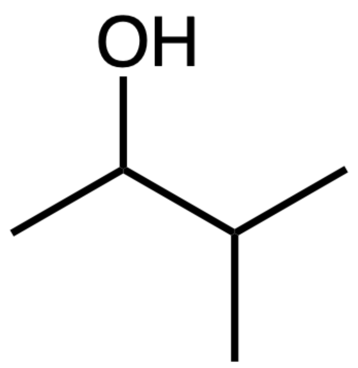
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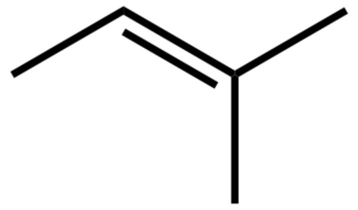
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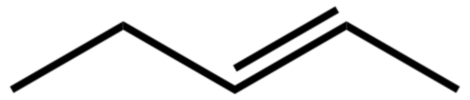
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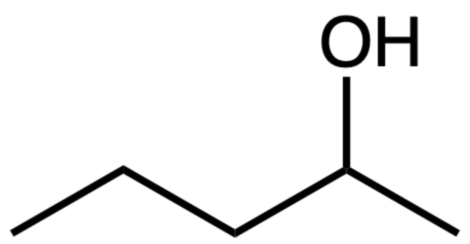
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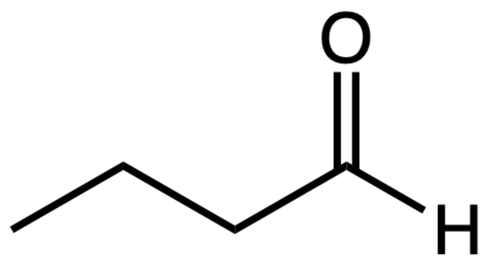
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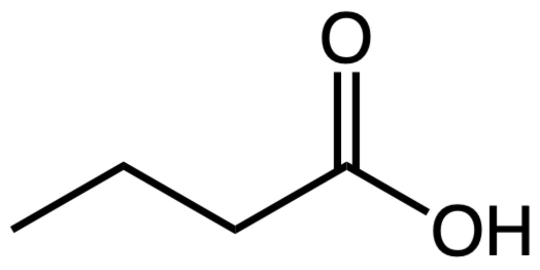
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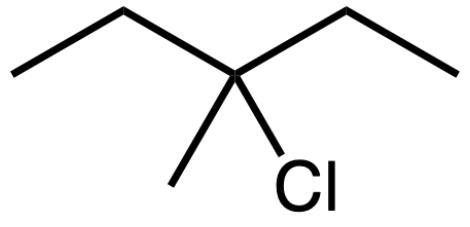
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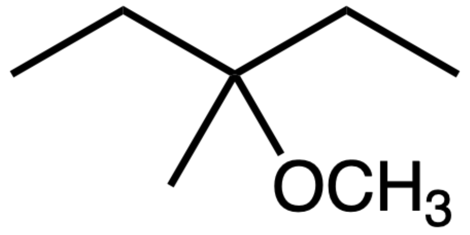
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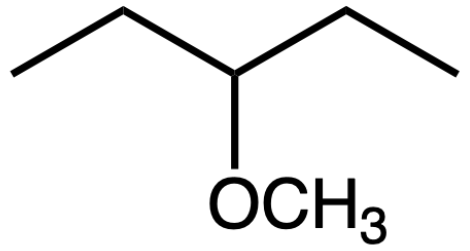
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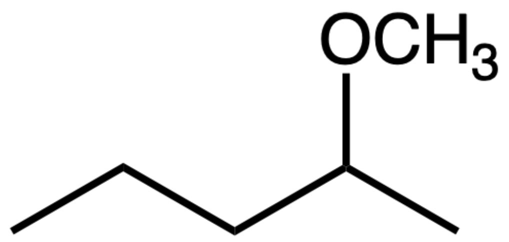
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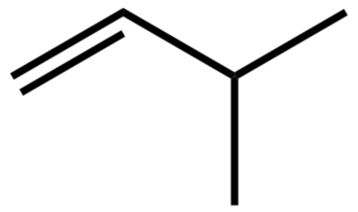
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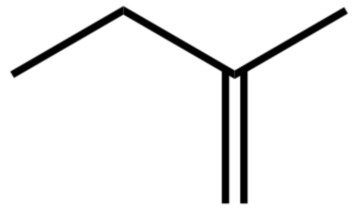
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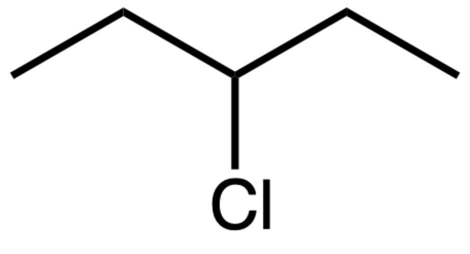
ORGANIC CHEMISTRY: PROBLEM 7.8

Which of the following compounds could exhibit geometric isomerism?

— answer —



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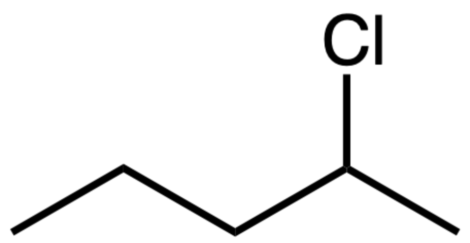

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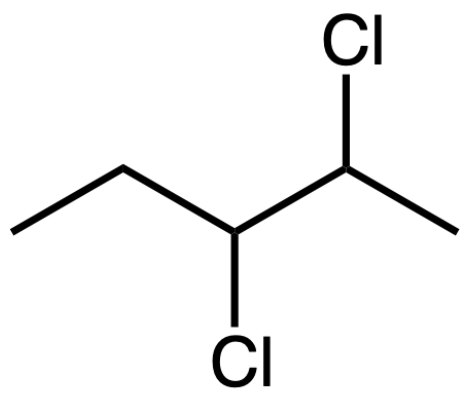

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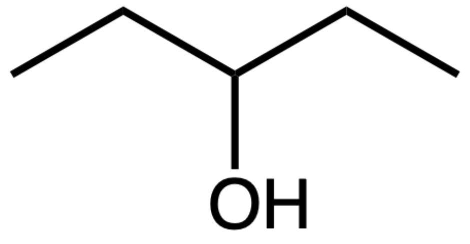

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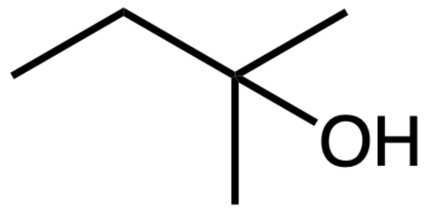

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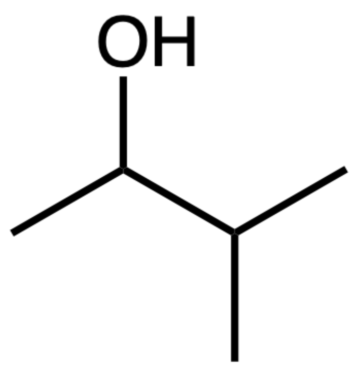

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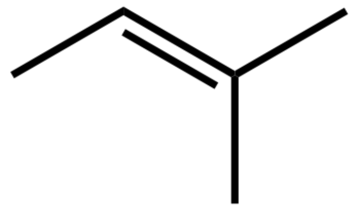

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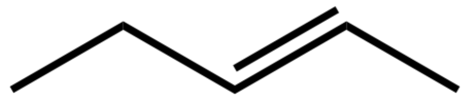

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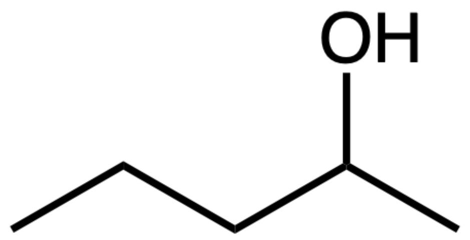

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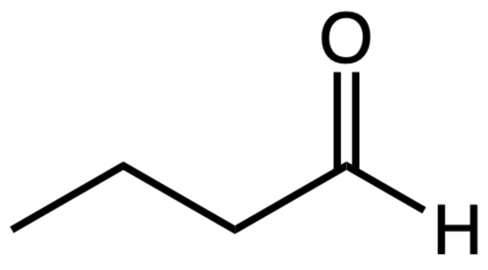

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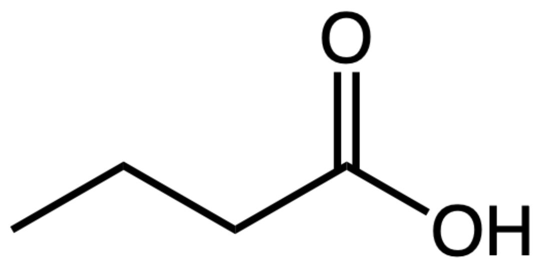

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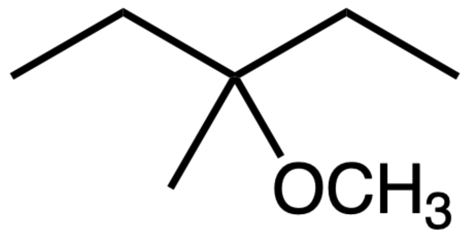

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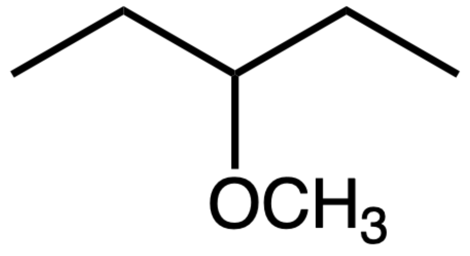

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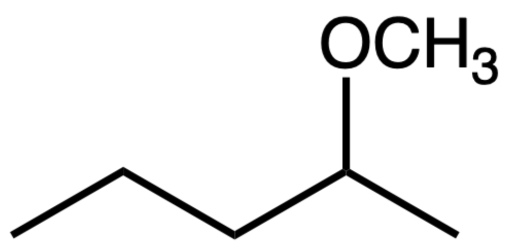

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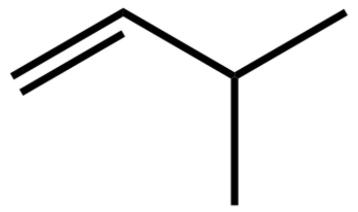

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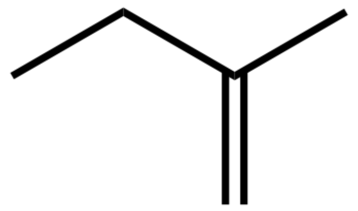

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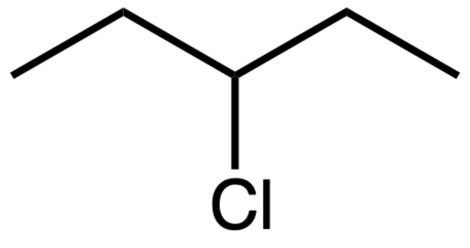
ORGANIC CHEMISTRY: PROBLEM 7.8

Which of the following compounds contains a chiral carbon center?

— answer —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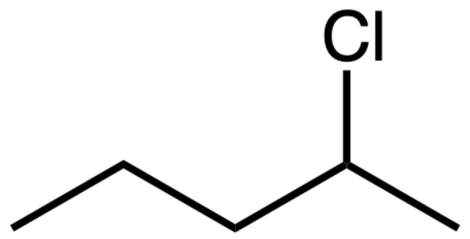
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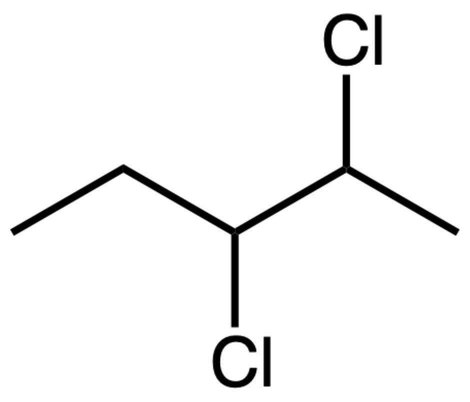
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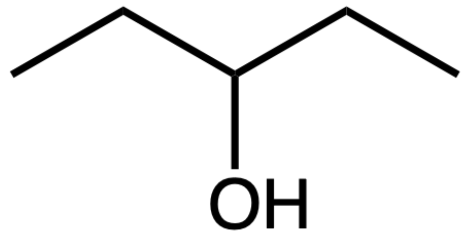
(4)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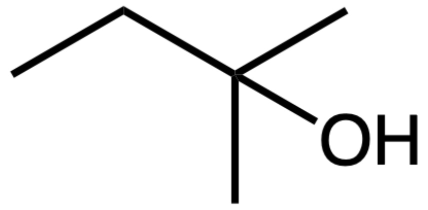
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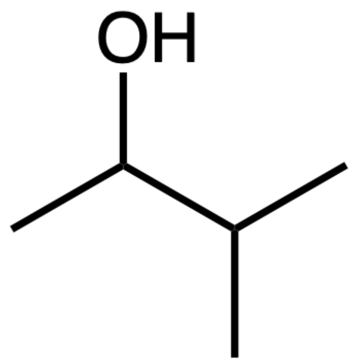
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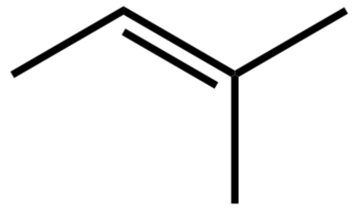
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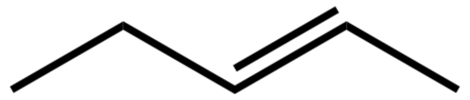
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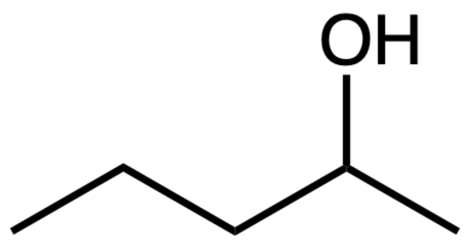
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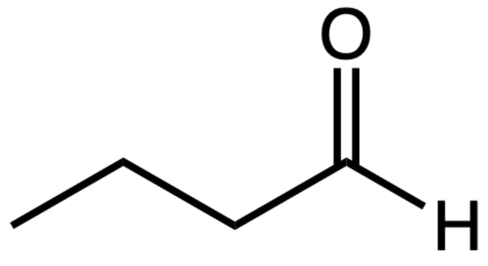
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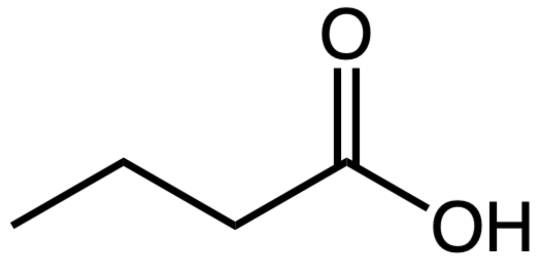
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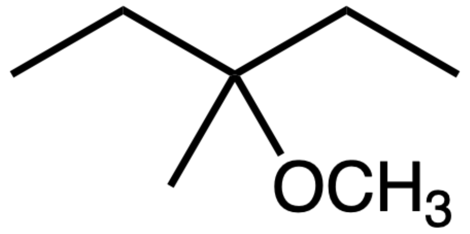
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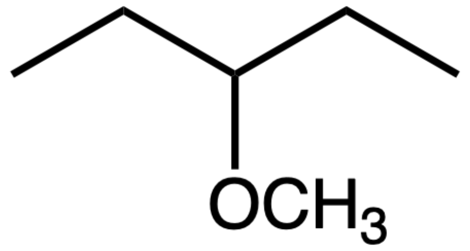
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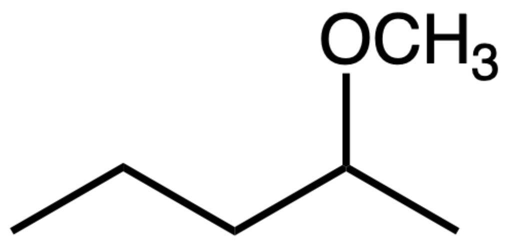
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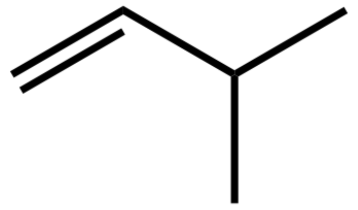
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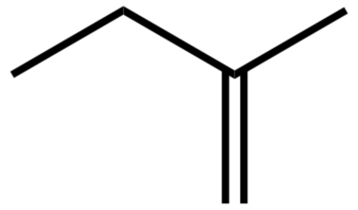
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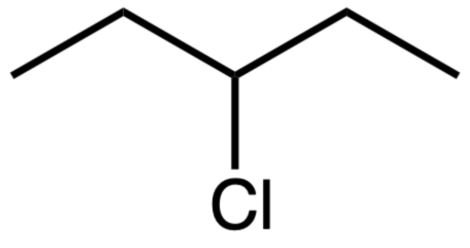
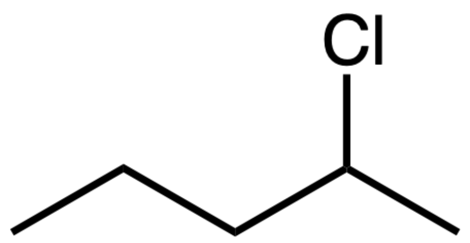
ORGANIC CHEMISTRY: PROBLEM 7.9

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

— answer —



(1)



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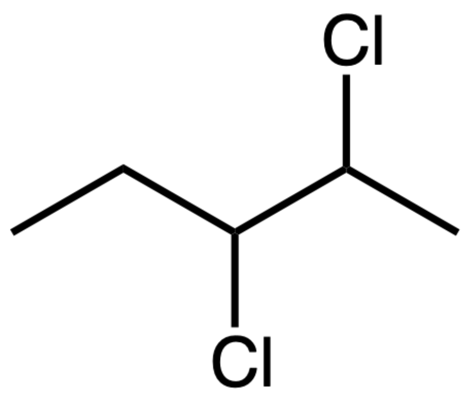

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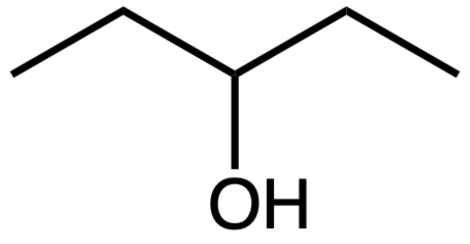

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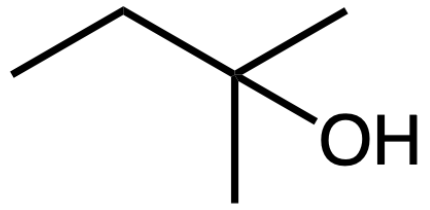

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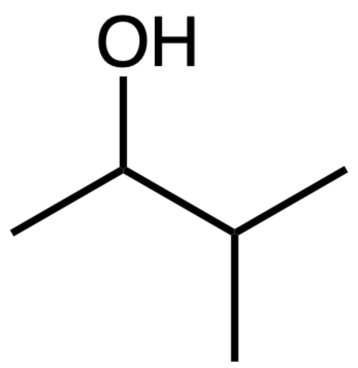

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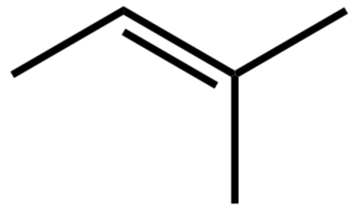

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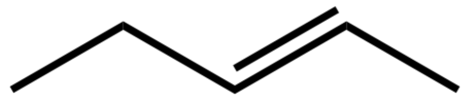

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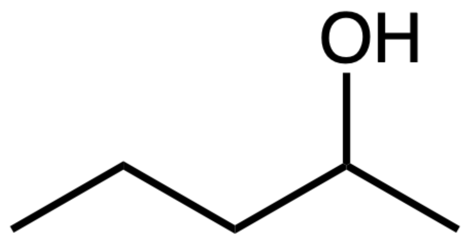

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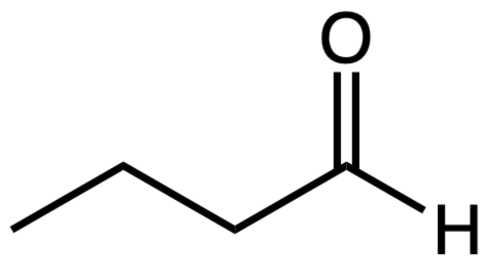

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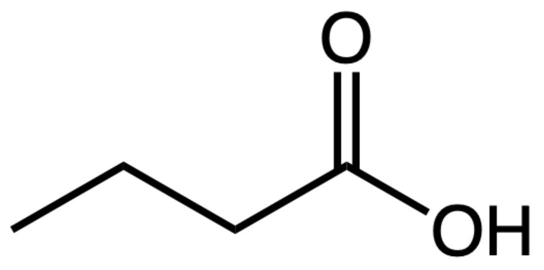

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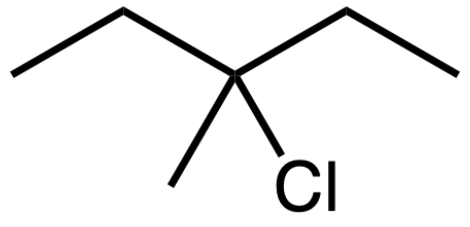

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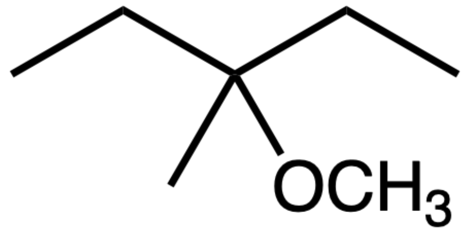

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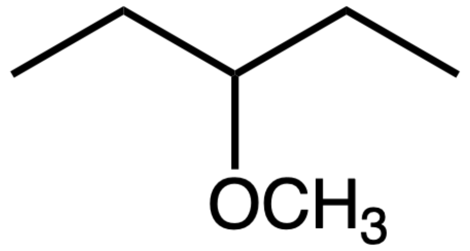

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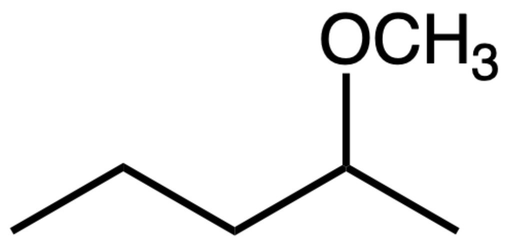

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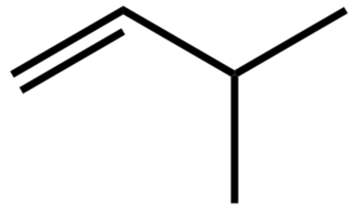

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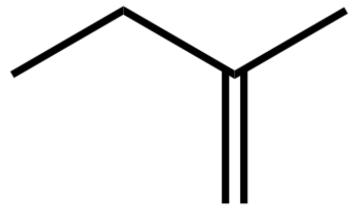
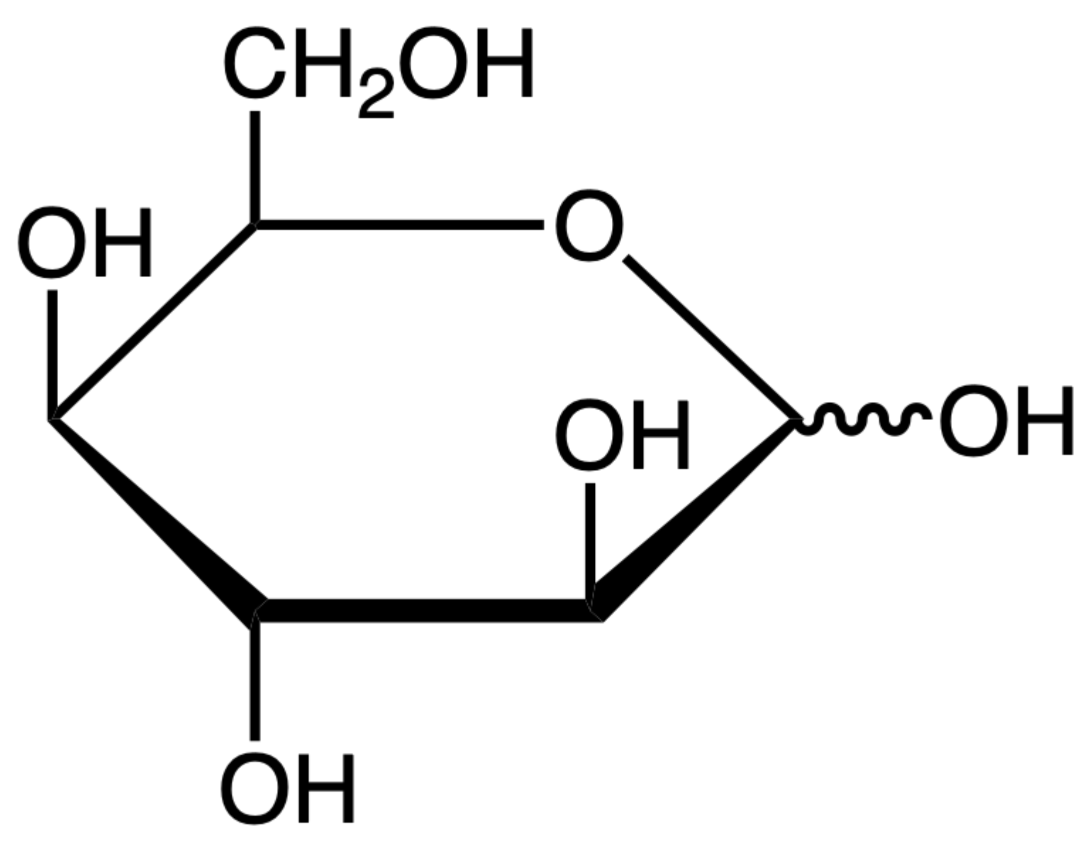


(18)

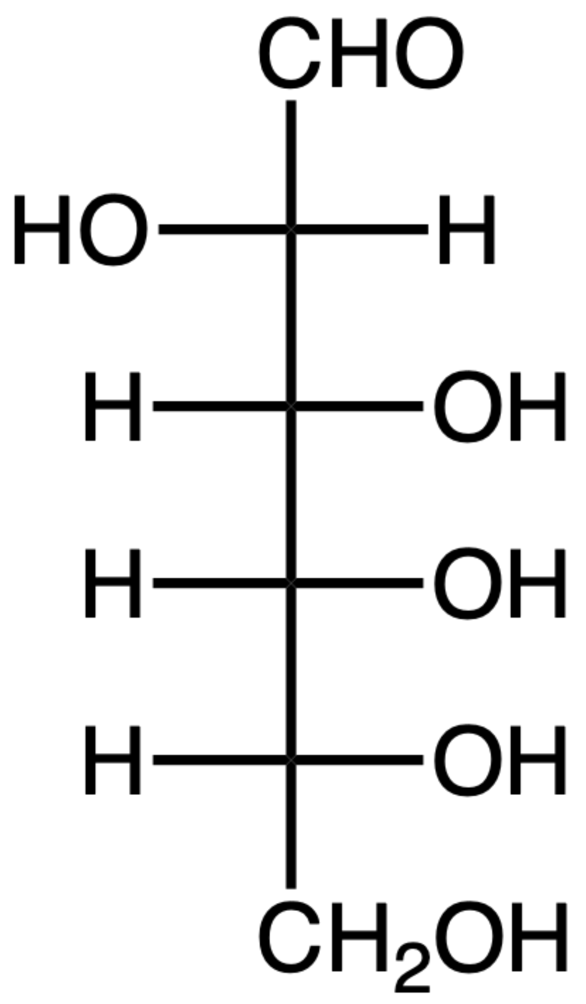
BIOCHEMISTRY: PROBLEM 8.1

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

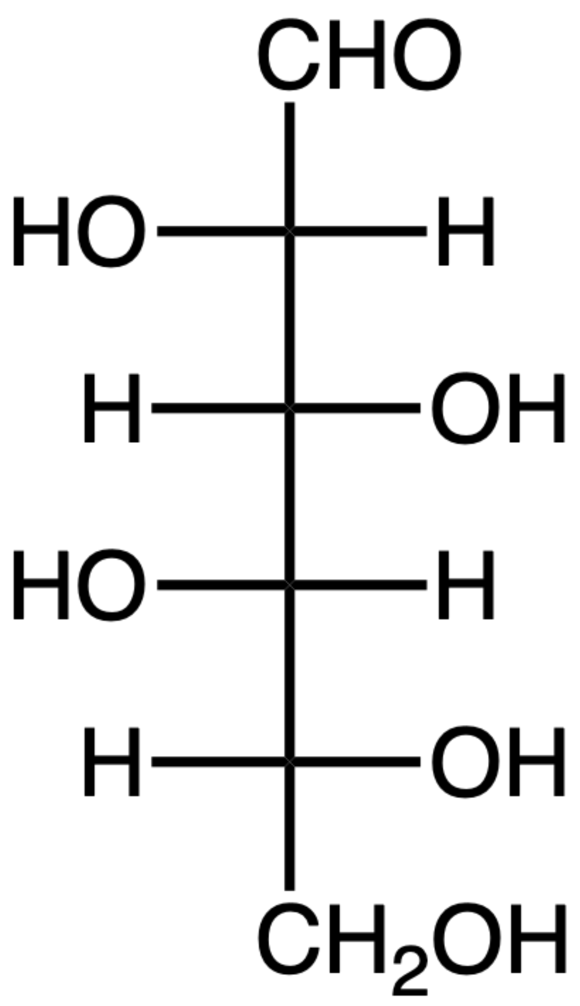
— *answer* —



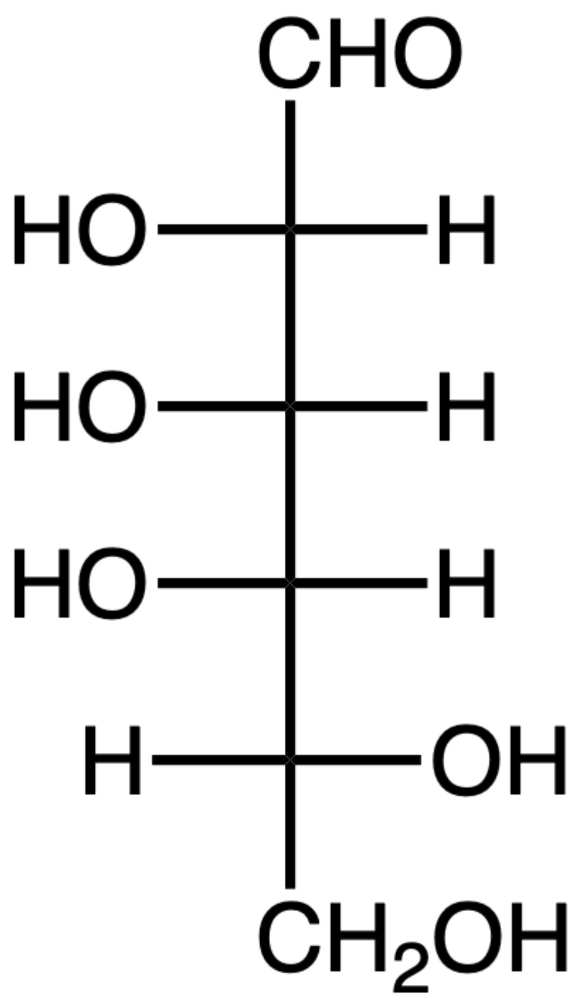
D-Idose



(A)



(B)

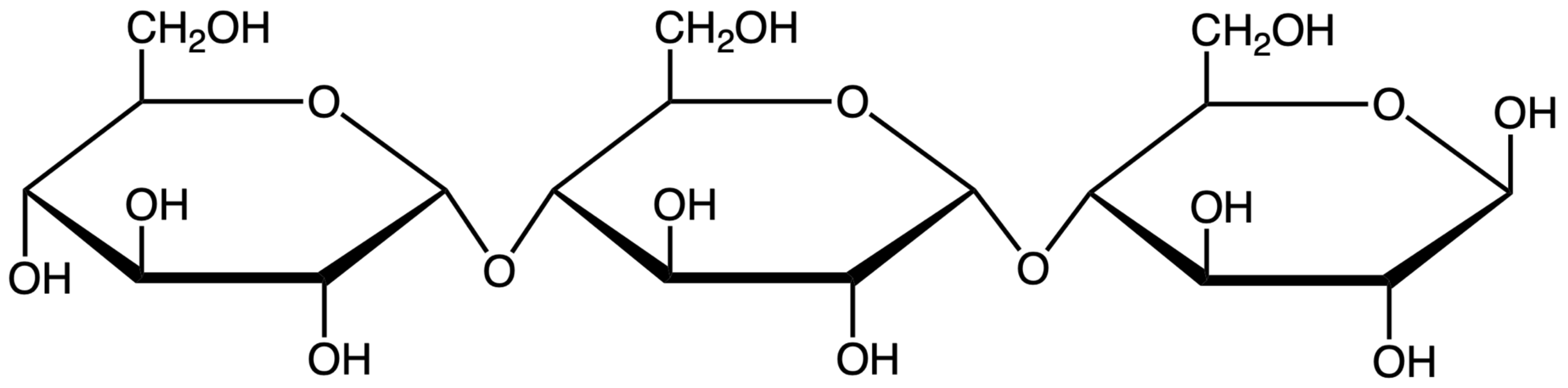


(C)

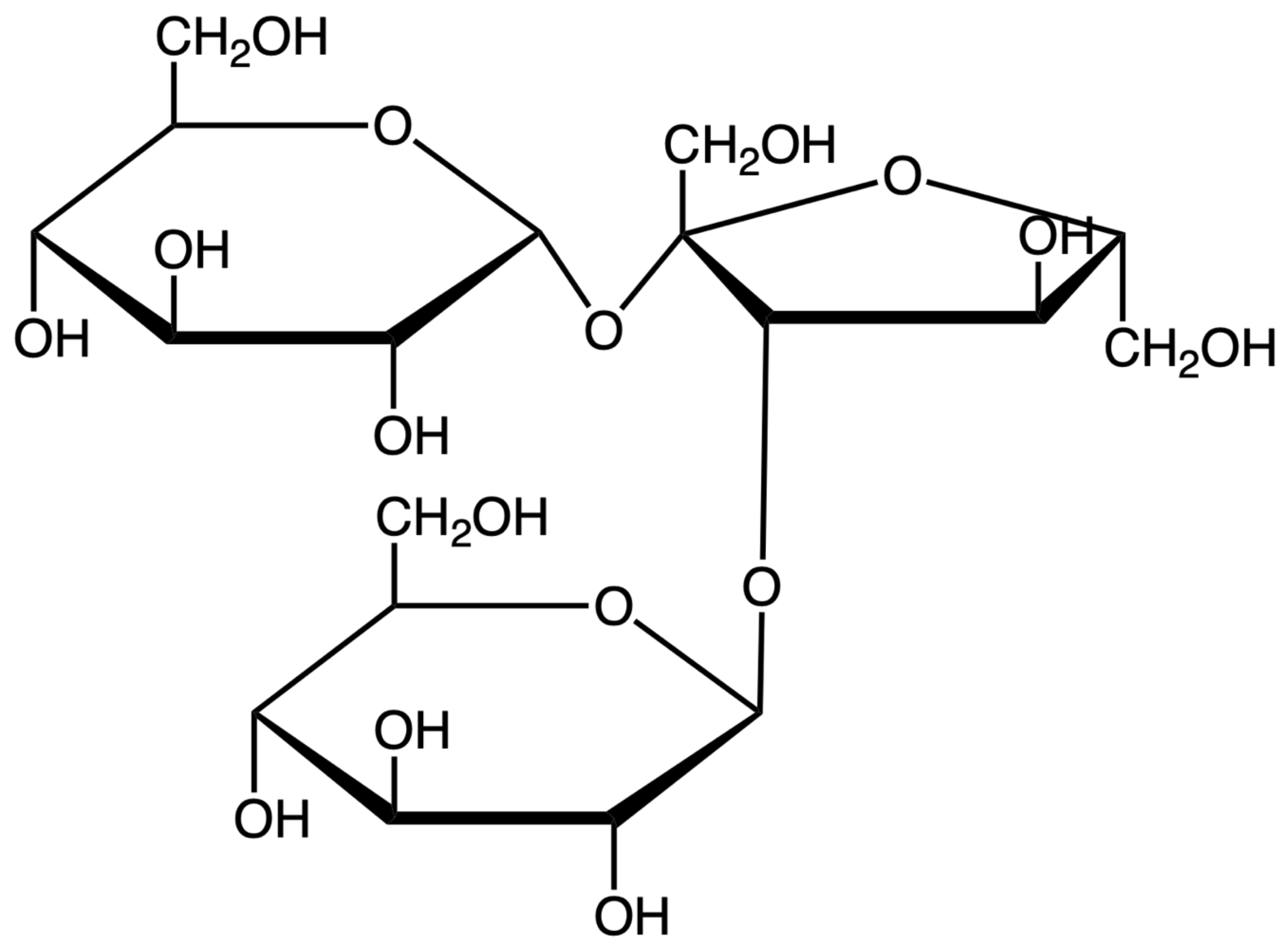
BIOCHEMISTRY: PROBLEM 8.2

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

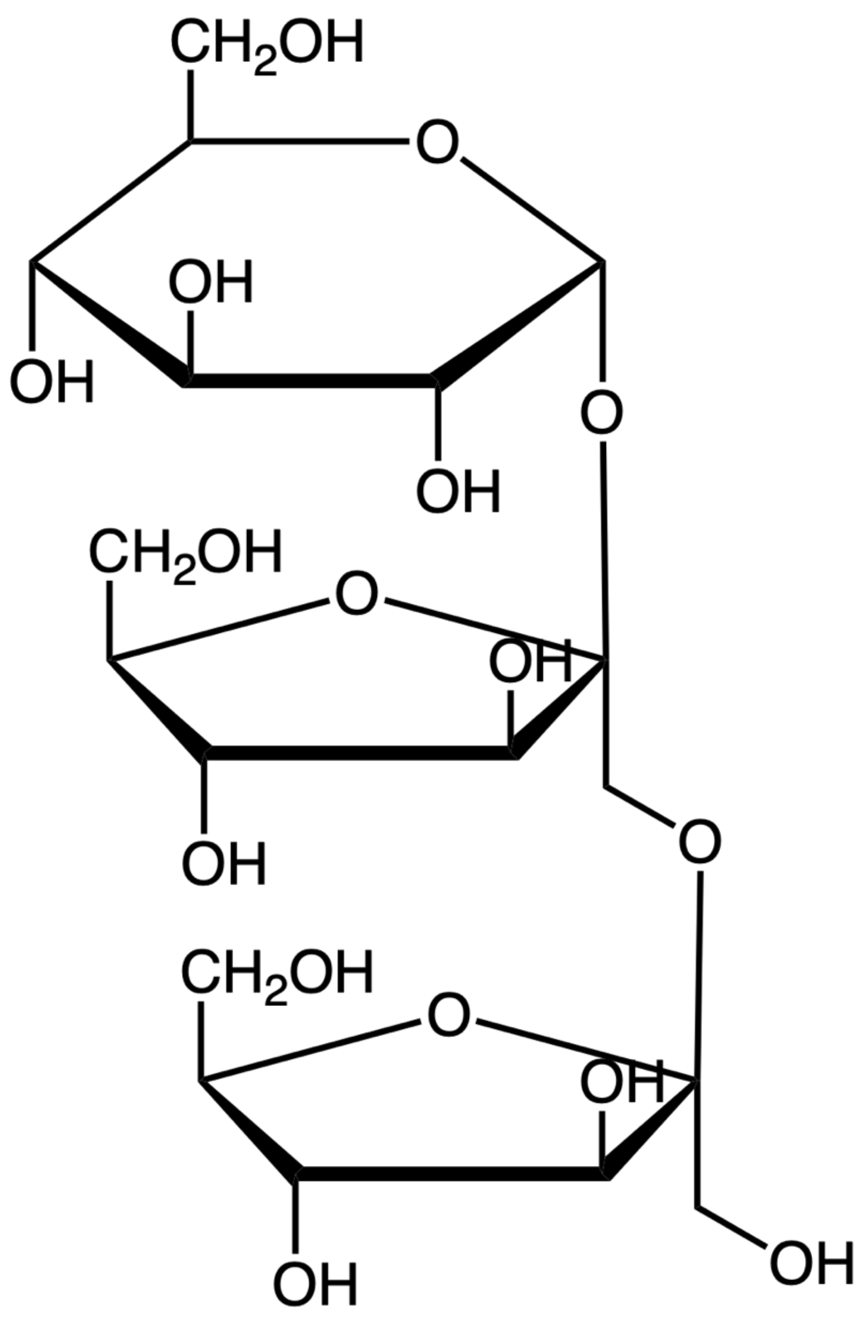
— answer —



Maltotriose



Melezitose

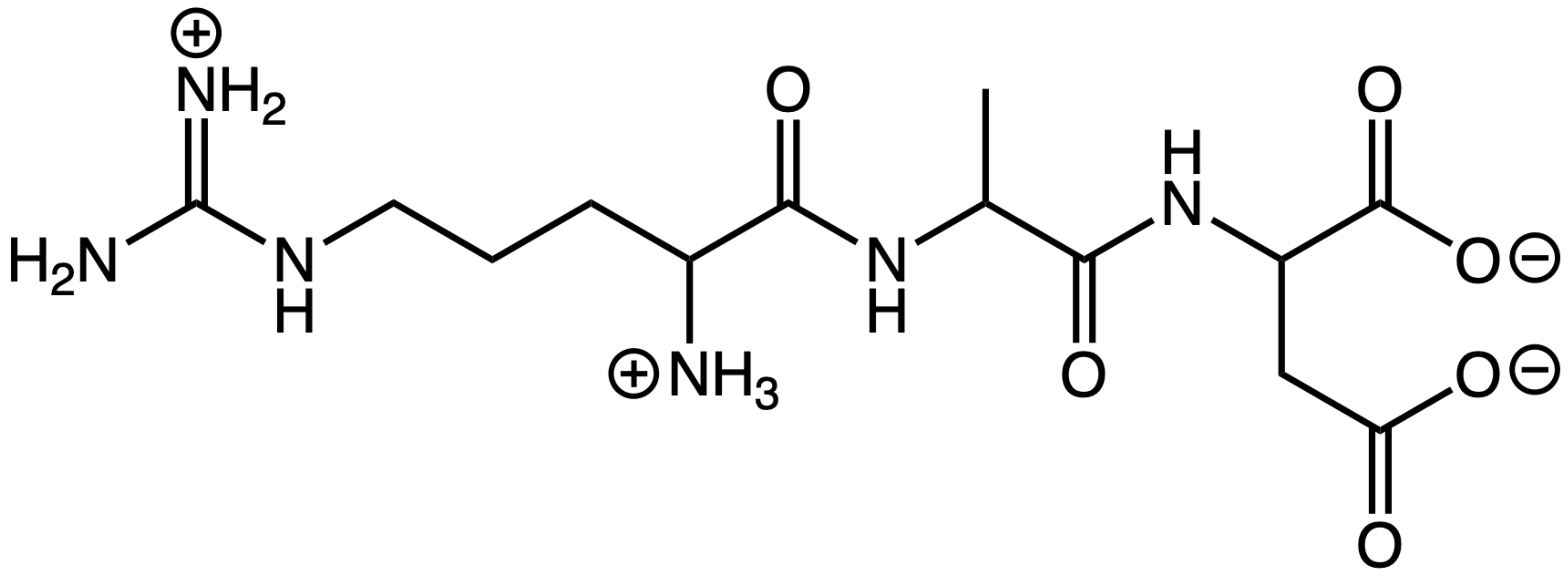


Kestose

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.

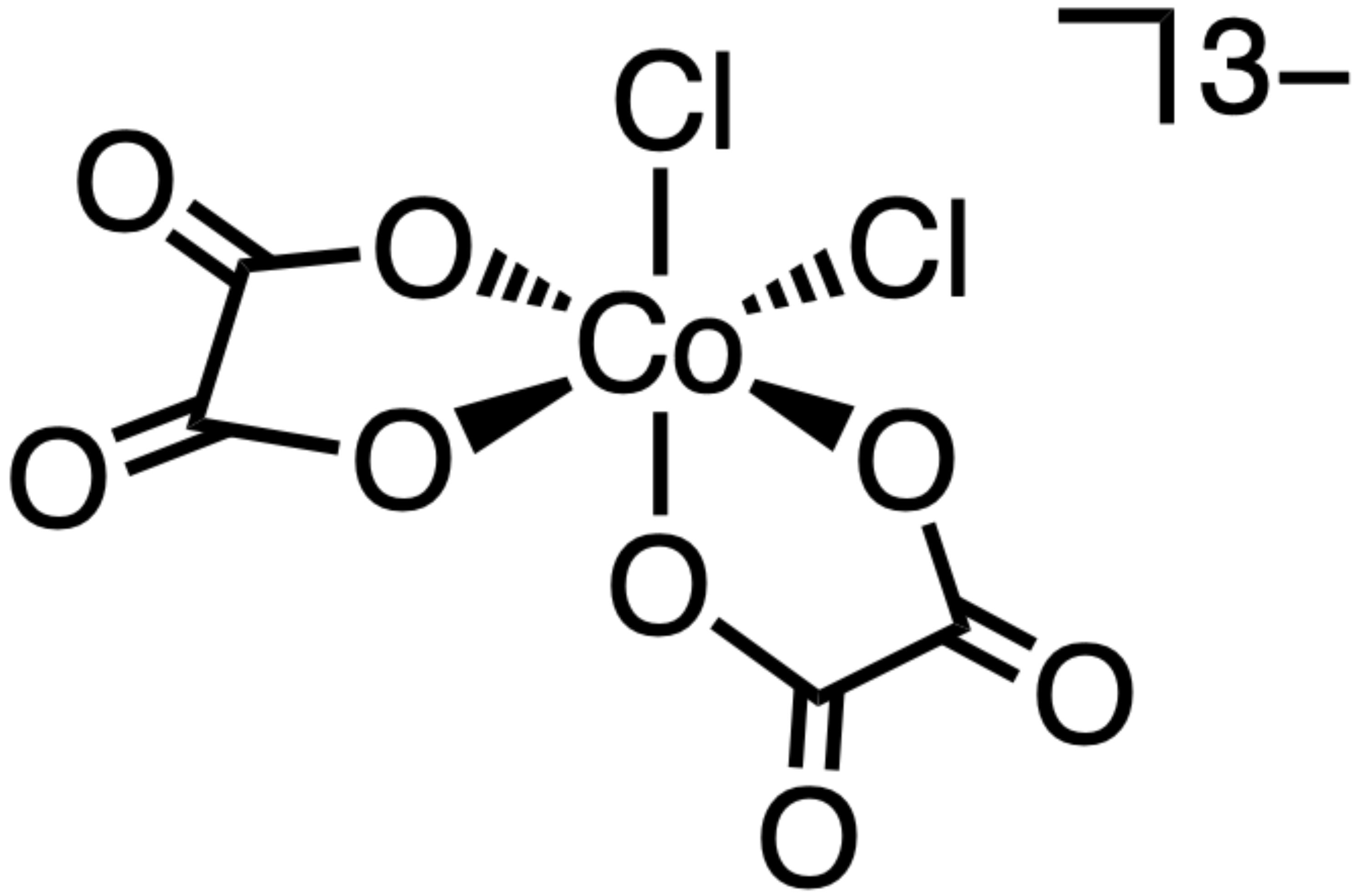
— answer —



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)	$[Co(NH_3)_6]Cl_3$				
	$K_3[CoF_6]$				