SI Chemistry - Full Discipline Demo

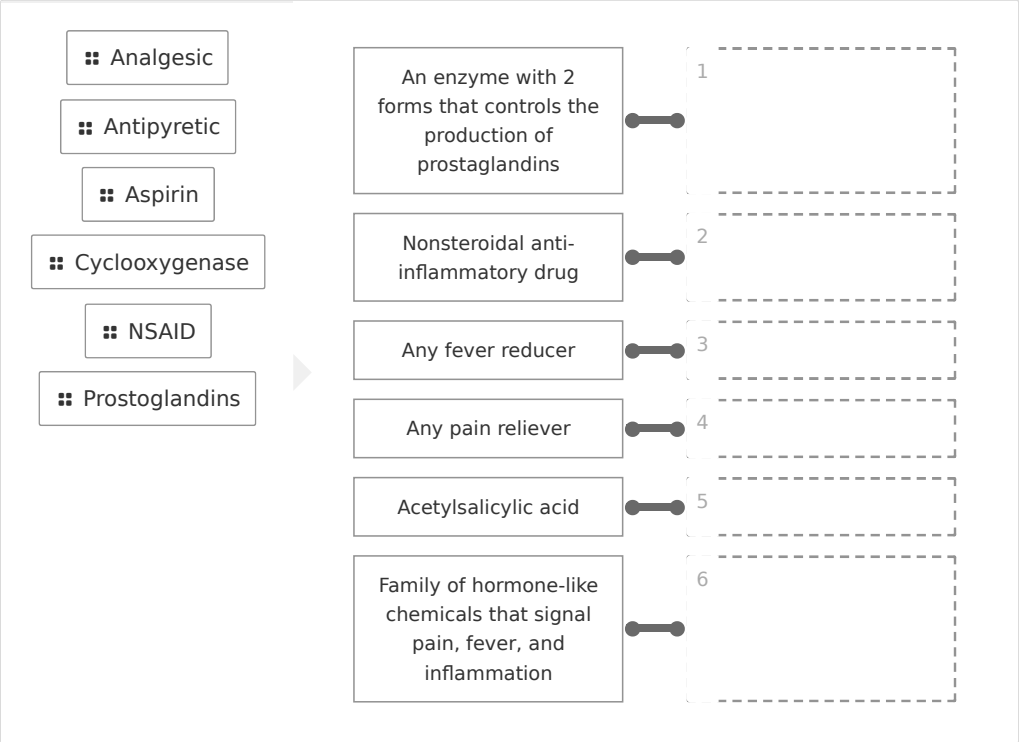
Hydrolysis of Acetylsalicylic Acid

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.



Correct answers:

1 Cyclooxygenase 2 NSAID 3 Antipyretic 4 Analgesic

5 Aspirin 6 Prostoglandins

Categorize each reaction as a condensation or hydrolysis reaction.

- 2 amino acids *yields* dipeptide + H_2O
- 3 fatty acids + glycerol *yields* triglyceride + $3H_2O$
- ester + H_2O *yields* carboxylic acid + alcohol
- starch + H_2O *yields* glucose
- tripeptide + H_2O *yields* 3 amino acids

Condensation Reaction	Hydrolysis Reaction
1	2

Correct answers:

1 2 amino acids *yields* dipeptide + H_2O

3 fatty acids + glycerol *yields* triglyceride + $3H_2O$

2 ester + H_2O *yields* carboxylic acid + alcohol

starch + H_2O *yields* glucose tripeptide + H_2O *yields* 3 amino acids

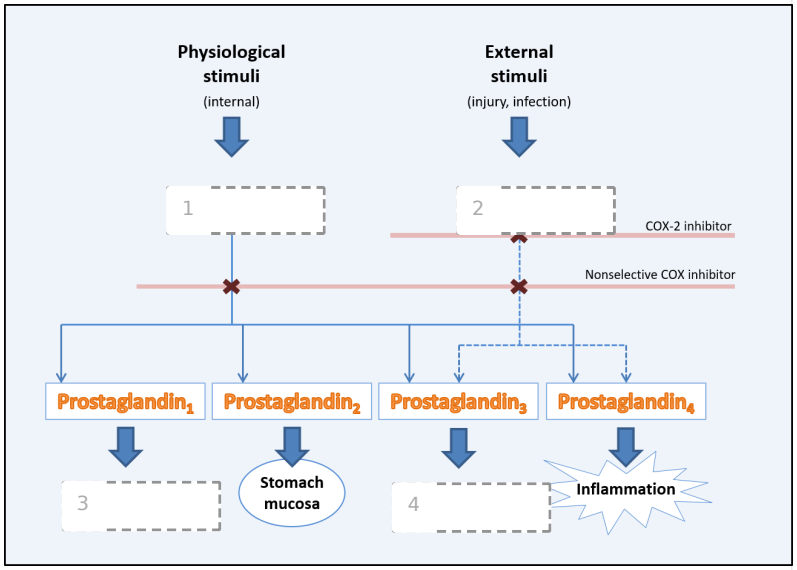
Label the diagram with the appropriate enzymes and responses.

COX-1

COX-2

Pain

Platelet function



Correct answers:

1 COX-1 2 COX-2 3 Platelet function 4 Pain

Categorize these commercially available NSAIDs. Categories may have more than one answer.

Advil®

Aspirin®

Celebrex®

COX-1 Inhibitor	COX-2 Inhibitor	Nonselective Inhibitor
1	2	3

Correct answers:

1 No correct answers set 2 Celebrex®

3 Advil® Aspirin®

Exploration

What class of drugs includes aspirin?

- [x] Nonsteroidal anti-inflammatory drugs
- [ ] Narcotics
- [ ] Stimulants
- [ ] Depressants

Aspirin is unique among the NSAIDs because it suppresses blood clotting for days, while most NSAIDs only affect clotting for a few hours.

- [x] True
- [ ] False

The production of cyclooxygenase is controlled by prostaglandins.

- [ ] True
- [x] False

COX-1 is responsible for the production of prostaglandins that signal inflammation, pain and also the prostaglandins that support platelet formation and the production of stomach mucosa.

- [x] True
- [ ] False

Hydrolysis means "to form using water."

- [ ] True
- [x] False

Adding water to an aspirin tablet yields _____.

- acetic acid and salicylic acid ✔
- acetic acid and sallypickle acid
- salicylic acid and sulfate heptahydrate

Le Chatelier's principle states that when a change is imposed on a chemical system, the system will act to _____ the total effect of the change.

- increase
- reduce ✔
- ignore

Exercise 1

Define the acronym NSAID. Why are NSAIDs valuable to medicine?

NSAIDs are Nonsteroidal Anti-Inflammatory Drugs (NSAIDs). NSAIDs are unique when compared to many other analgesics because they are not narcotics, meaning that they do not depress the central nervous system.

What property of aspirin makes it unique among the NSAIDs?

Aspirin is unique among the NSAIDs because it suppresses blood clotting for days, while most NSAIDs only affect clotting for hours.

Define the roles of the cyclooxygenase enzyme and prostaglandins in the body. What types of stimuli prompt the production of the two forms of the cyclooxygenase enzyme?

A physiological or external stimulus initiates the production of the enzyme cyclooxygenase: COX-1 and/or COX-2. COX-1 is responsible for the prostaglandins that support blood clotting and protect the lining of the stomach. Both COX-1 and COX-2 are responsible for the production of prostaglandins that signal inflammation, pain, and fever. Physiological (internal) stimuli may prompt the production of COX-1. External stimuli, such as injury or infection, prompt the production of COX-2.

How do NSAIDs work to block pain?

NSAIDs block COX enzymes or attach to the enzymes and change their chemical structure so that there is no signal for the production of prostaglandins. The result is a cessation of the message for the body to feel pain.

In Data Table 1, which NSAIDs are selective for COX-2?

Only Celebrex is selective for COX-2.

According to Data Table 1, what are some ailments that all of the NSAIDs treat?

Arthritis, menstrual cramps, sports injuries, or swelling.

Identify four general properties that make an NSAID unique as compared to the NSAID aspirin. List specific properties that make aspirin, naproxen, and ibuprofen unique from one another.

NSAIDs may produce fewer or more side effects than aspirin, have greater distribution within the body's tissues, be more potent, or have a greater half-life.
Aspirin: irreversible COX inhibitor, reduces platelet function for up to 7 days.
Naproxen: reversible COX inhibitor, half-life of approximately 14 hours.
Ibuprofen: reversible COX inhibitor, half-life of approximately 2 hours.

Data Table 1: Comparison of Common NSAIDs
(SAMPLE ANSWER BELOW)

Generic Name	Commercial Brand Name(s)	Prescription Only	Typical Uses	Enzymes Inhibited	Source(s)
Meloxicam	Mobic	X	Reduce pain and swelling associated with osteoarthritis and rheumatoid arthritis	COX-1 & COX-2	Indicate your resources here
Aspirin	Ascriptin, Bayer, Ecotrin		Pain, swelling, arthritis, fever, toothache, menstrual pain, blood thinning	COX-1 & COX-2	
Naproxen	Aleve, Anaprox, Naprelan, Naprosyn		Arthritis, ankylosing spondylitis, gout, bursitis, menstrual cramps	COX-1 & COX-2	
Ibuprofen	Motrin, Advil		Pain, swelling, arthritis, fever, toothache, menstrual pain	COX-1 & COX-2	
Celecoxib	CELEBREX	X	Arthritis, colorectal polyps, injuries and menstrual cramps	COX-2	
Diclofenac	Cataflam, Voltaren	X	Arthritis, ankylosing spondylitis, tendonitis, bursitis, menstrual cramps	COX-1 & COX-2	No sample answer

Exercise 2

Define equilibrium. How is equilibrium denoted in a written chemical equation?

When a system is at equilibrium, a fixed concentration of reactants exist in conjunction with a fixed concentration of products. The forward reaction and the

reverse reaction occur at the same rate. Double arrows indicate that the reaction is at equilibrium.

Draw the molecules involved in the synthesis of aspirin on a sheet of paper. Take a photo of the drawn molecules and upload the image into Photo 7.

Observe the reaction you drew in Photo 7. Is the forward reaction hydrolysis or condensation? Is the reverse reaction hydrolysis or condensation? Describe what occurs in each type of reaction with respect to acetylsalicylic acid.

Forward reaction = condensation
Salicylic acid loses a hydrogen. Acetic acid loses a hydroxyl group and the carbon bonds with the open oxygen of salicylic acid. Acetylsalicylic acid is produced.
Reverse reaction = hydrolysis
Water breaks the oxygen-carbon bond of acetylsalicylic acid, yielding salicylic acid and acetic acid. One hydrogen atom of water is donated, forming salicylic acid, and the OH portion is donated to form acetic acid.

What was the purpose of test tube A in the experiment?

Test tube A served as a control since it contained only distilled water and $FeCl_3$.

State Le Châtelier's principle in your own words. Explain how Le Châtelier's principle was used in Exercise 2. Compare and reference Data Table 2 and Data Table 3 in your answer.

Le Châtelier's principle states that when a change is imposed on a chemical system, the system will act to reduce the total effect of the change. Water was added to aspirin, favoring the reverse reaction, and salicylic acid and acetic acid were produced. This was demonstrated by a dark purple solution forming in test tube B after 12 hours. The purple hue is produced by the bonding of iron ions with salicylic acid. Test tube A contained only distilled water and iron ions and remained yellow throughout the experiment.

How did exposing the aspirin powder to air for 8 to 12 hours affect its composition? Compare and reference Data Table 2 and Data Table 4.

Le Châtelier’s principle states that when a change is imposed on a chemical system, the system will act to reduce the total effect of the change. Water was added to aspirin, favoring the reverse reaction, and salicylic acid and acetic acid were produced. This was demonstrated by a dark purple solution forming in test tube B after 12 hours. The purple hue is produced by the bonding of iron ions with salicylic acid. Test tube A contained only distilled water and iron ions and remained yellow throughout the experiment.

Data Table 2: Test Tube A (H_2O + $FeCl_3$) and Test Tube B (H_2O + $FeCl_3$ + Aspirin) at Beginning of Experiment

(SAMPLE ANSWER BELOW)

Test Tube	Description	Salicylic Acid Presence
A	Clear yellow solution	No, a yellow solution indicates that salicylic acid not present.
B	Clear light purple solution	Yes, a light purple solution indicates the presence of salicylic acid.

Photo 1: Test Tube A at Beginning of Experiment

(SAMPLE ANSWER BELOW)

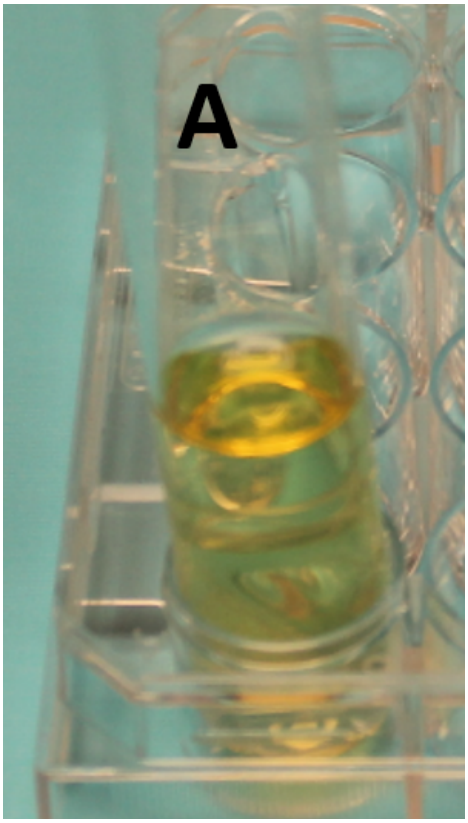
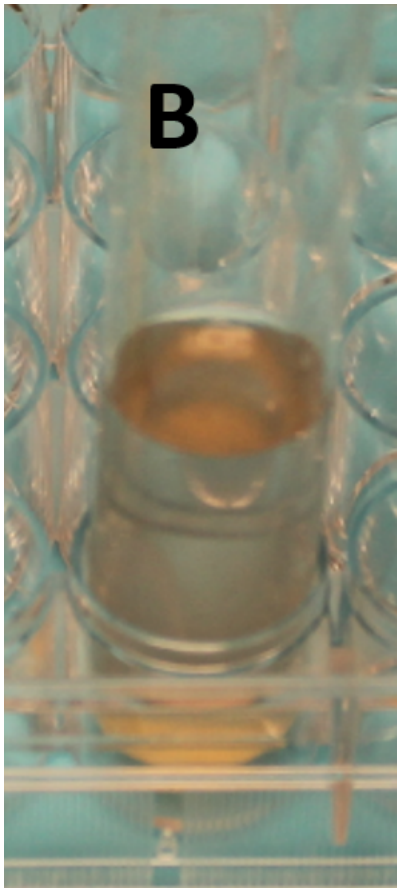


Photo 2: Test Tube B at Beginning of Experiment
(SAMPLE ANSWER BELOW)



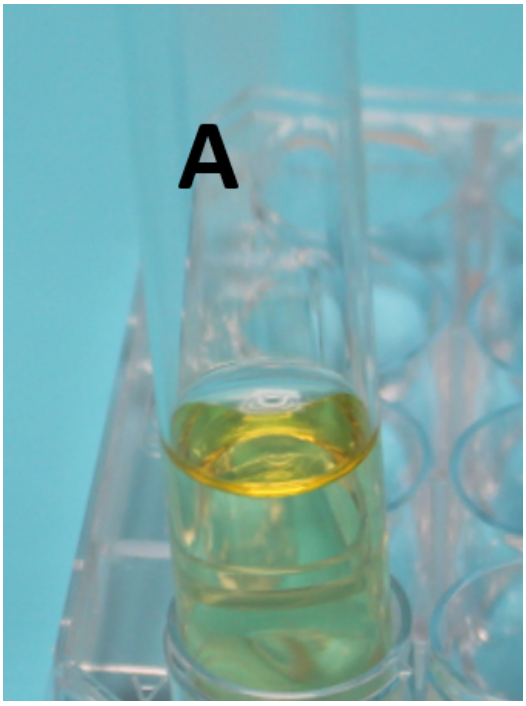
Data Table 3: Test Tube A (H2O + FeCl3) and Test Tube B (H2O + FeCl3 + Aspirin) after 8-12 Hour Reaction Period

(SAMPLE ANSWER BELOW)

Test Tube	Description	Salicylic Acid Presence
A	Clear yellow solution	No, a yellow solution indicates that salicylic acid is not present.
B	Clear dark purple solution	Yes, a dark purple solution indicates the presence of salicylic acid.

Photo 3: Test Tube A after 8-12 Hour Reaction Period

(SAMPLE ANSWER BELOW)



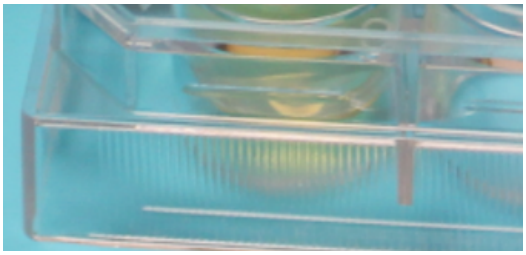
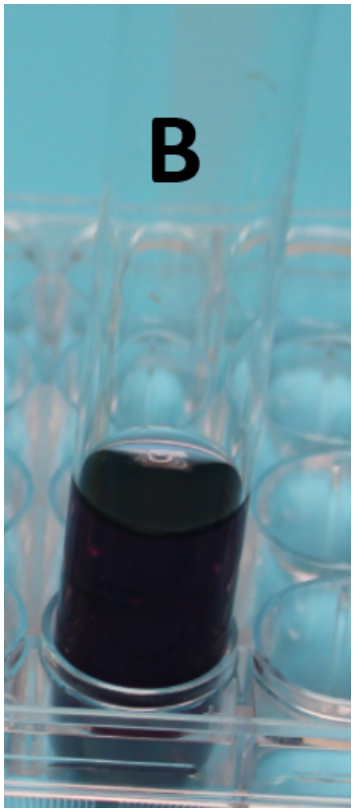


Photo 4: Test Tube B after 8-12 Hour Reaction Period
(SAMPLE ANSWER BELOW)



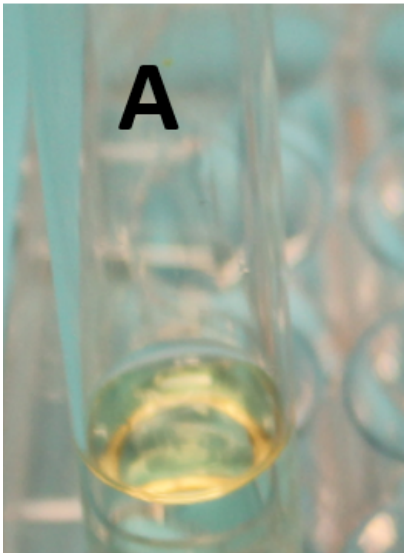
Data Table 4: Test Tube A (H_2O + $FeCl_3$) and Test Tube C (H_2O + $FeCl_3$ + Aspirin Exposed to Air for 8-12 Hours)

(SAMPLE ANSWER BELOW)

Test Tube	Description	Salicylic Acid Presence
A	Clear yellow solution	No, a yellow solution indicates that salicylic acid is not present.
C	Clear medium purple solution	Yes, a medium purple solution indicates the presence of salicylic acid.

Photo 5: Test Tube A

(SAMPLE ANSWER BELOW)



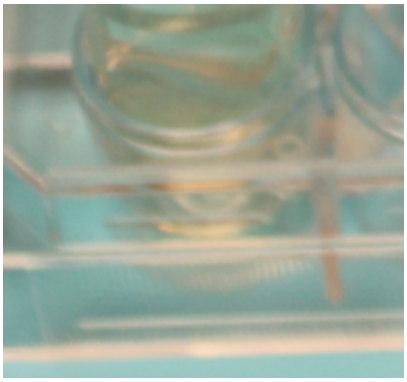
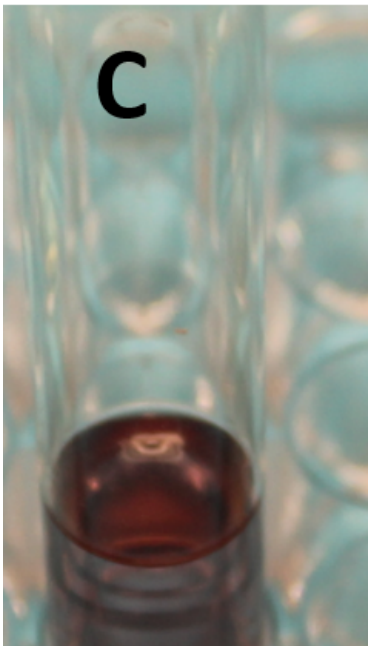


Photo 6: Test Tube C
(SAMPLE ANSWER BELOW)



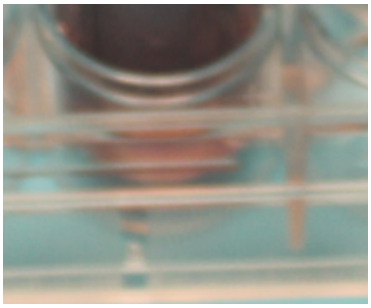
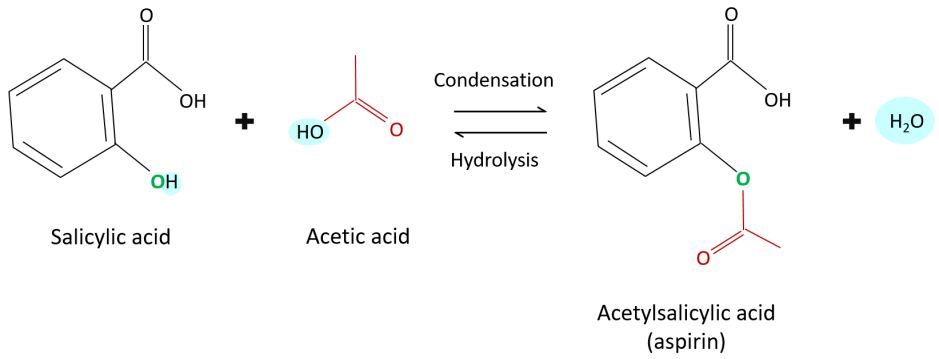


Photo 7: Question 2 Drawn Molecules

(SAMPLE ANSWER BELOW)



Competency Review

Aspirin is used as an____.

- antipyretic
- anti-inflammatory
- analgesic
- All of the above ✔

NSAIDs, like many other analgesics, relieve pain and inflammation due to their narcotic properties.

- True
- False ✔

The flow of signaling from stimulus to a pain symptom is _____.

- stimulus - COX - prostaglandin - pain ✔
- stimulus - prostaglandin - COX - pain

Inflammation, pain, and fever are induced by a family of hormone-like chemicals called _____.

- prostaglandins ✔
- cyclooxygens
- nonselective inhibitors

NSAIDs prevent the production of prostaglandins by physically blocking the movement of COX enzymes, or attaching to COX enzymes, changing their chemical structure and function.

- True ✔
- False

Aspirin _____, while other NSAIDS _____.

- blocks the pathway of COX; chemically change the form of COX.
- chemically changes the form of COX; block the pathway of COX ✔

Other NSAIDs differ from aspirin due to _____.

- fewer or more side effects
- greater distribution in the body's tissues
- potency
- greater half-life
- All of the above ✔

Aspirin, Advil, and Celebrex are common COX-1 inhibitors.

- True
- False ✔

A hydrolysis reaction occurs when a larger organic molecule (an ester) is broken down into the smaller organic molecules (an acid and an alcohol) by the addition of water.

- True ✔
- False

A _____ reaction is when two organic molecules combine to form one organic molecule and a water molecule is released.

- hydrolysis
- equilibrium
- condensation ✔

Le Châtelier's Principle states that when a change is imposed on a chemical system, the system will act to reduce the total effect of the change.

- True ✔
- False

What NSAID would most likely be prescribed for a patient with osteoarthritis?

- Meloxicam ✔
- Aspirin
- Ibuprofen
- Tylenol

The commercial brands Motrin and Advil are types of _____.

- diclofenac
- aspirin
- naproxen
- ibuprofen ✔

Iron ions bond with _____ in solution to produce a purple color.

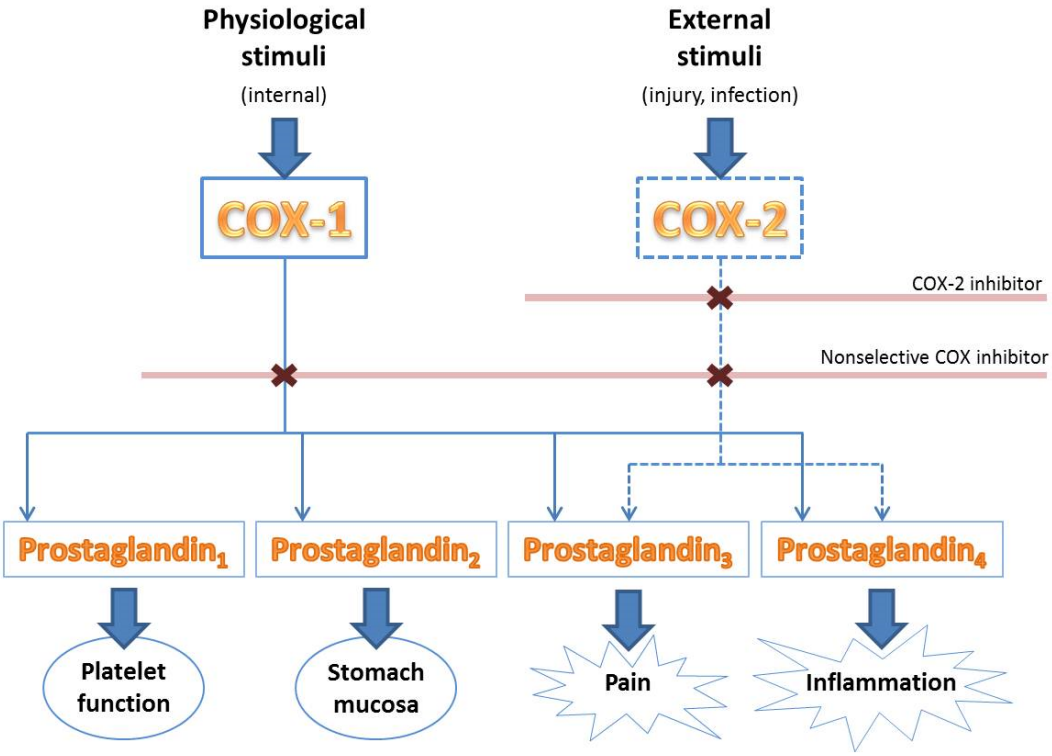
- acetylsalicylic acid
- acetic acid
- salicylic acid ✔
- water

Hydrolysis of acetylsalicylic acid can only occur in an aqueous solution.

- True
- False ✔

Extension Questions

Prescribe a class of medication to each of the following patients. Explain your choices. Refer to your work in the Experimentation section as necessary.



Patient 1: An elderly arthritic patient with recurring ulcers.
Patient 2: A teenage girl with moderate menstrual cramps.
Patient 3: A golfer with tendonitis.
Patient 4: A patient with a severe ankle sprain that is also complaining of heartburn and upset stomach.

(SAMPLE ANSWER BELOW)

Patient 1: The elderly arthritic patient with reoccurring ulcers will need a medication like Celebrex to aid in the reduction of arthritis. Celebrex would work better than other medication because it will not irritate the stomach like other nonselective COX inhibitors.
Patient 2: The teenage girl with moderate menstrual cramps could use Ibuprofen or naproxen. The nonselective COX inhibitor will work well and give her the greatest benefit.
Patient 3: Golfer with tendonitis could use naproxen. The nonselective COX inhibitor will work well and give the patient pain relief benefit for a long time frame than Ibuprofen.
Patient 4: Sever ankle sprain patient that is also complaining of heartburn and stomach upset might need to be prescribed Celebrex to avoid the side effects of a nonselective COX inhibitor.