

Hazardous Materials for First Responders

4th Edition

Chapter 4 — Chemical Properties and Hazardous Materials Behavior

**HAZ MAT FOR
FIRST RESPONDERS**

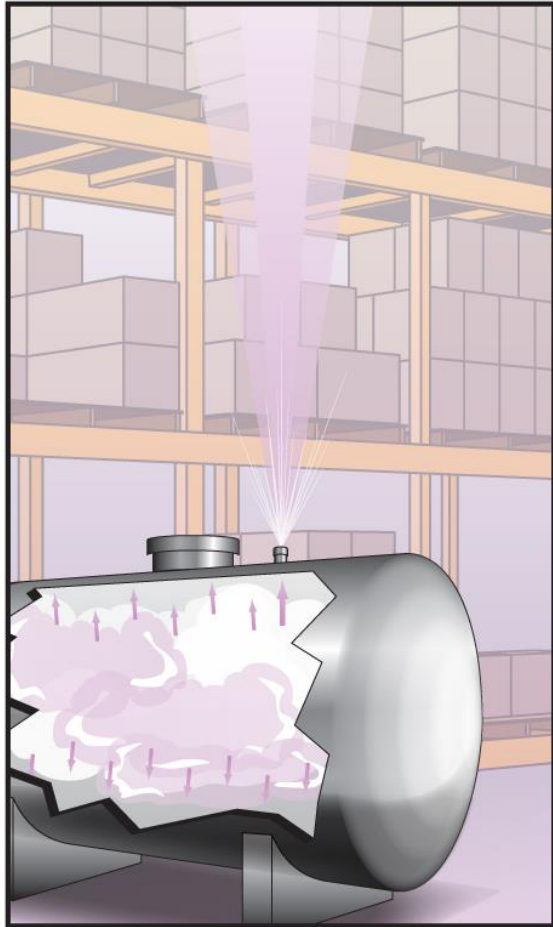


International Fire Service Training Association

Learning Objective 1

Discuss the three states of matter.

Gas, one state of matter, tends to expand indefinitely.



Fluid
with
neither

Independent shape

Volume

May
present
potential

Breathing/inhalation
hazard

Contact hazard

Liquid, one state of matter, may give off vapors.



Fluid
with

NO independent
shape

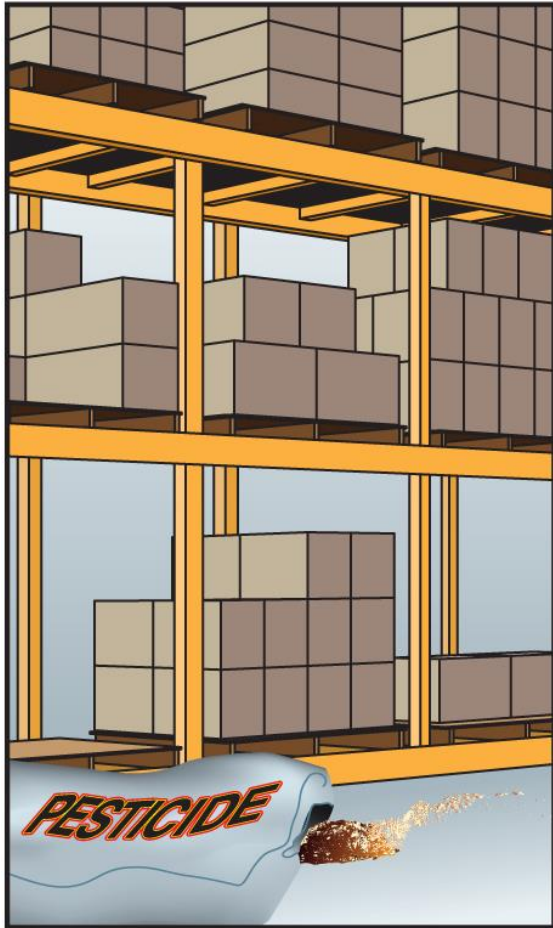
Specific volume

Flow
effected
by

Gravity

Surface contours

Solid, one state of matter, often stays in place unless acted upon.



Substance
with

Specific shape

Specific
volume

Moves

When
effected by
exterior forces

REVIEW QUESTION

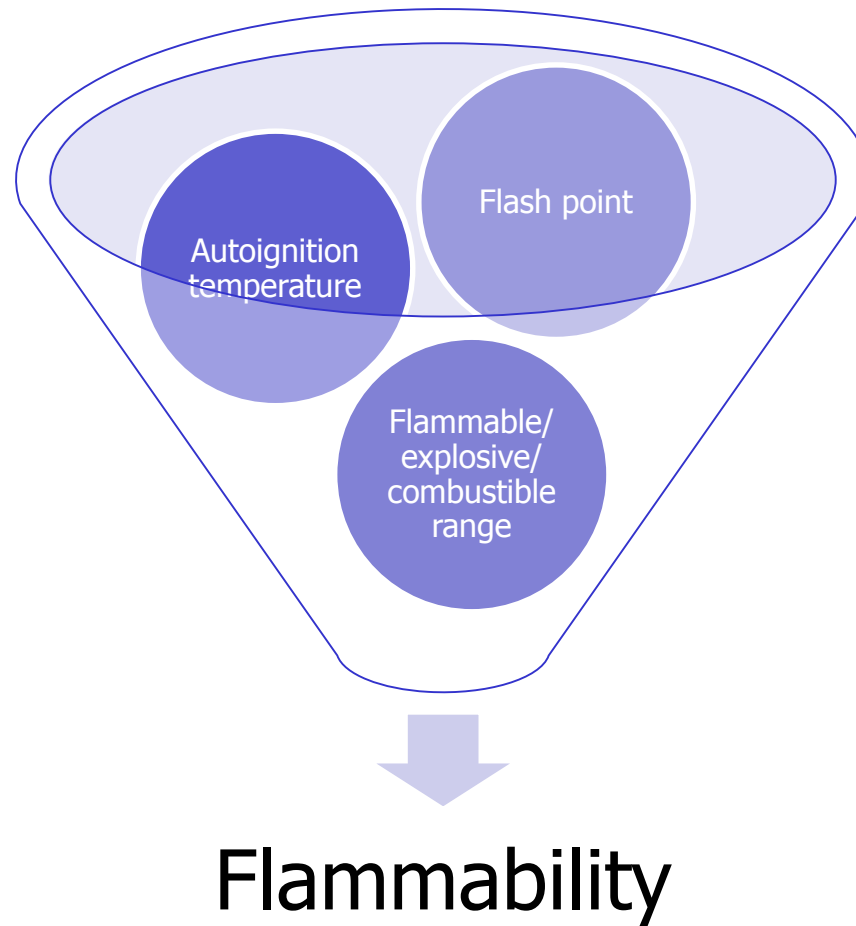


Describe the three states of matter.

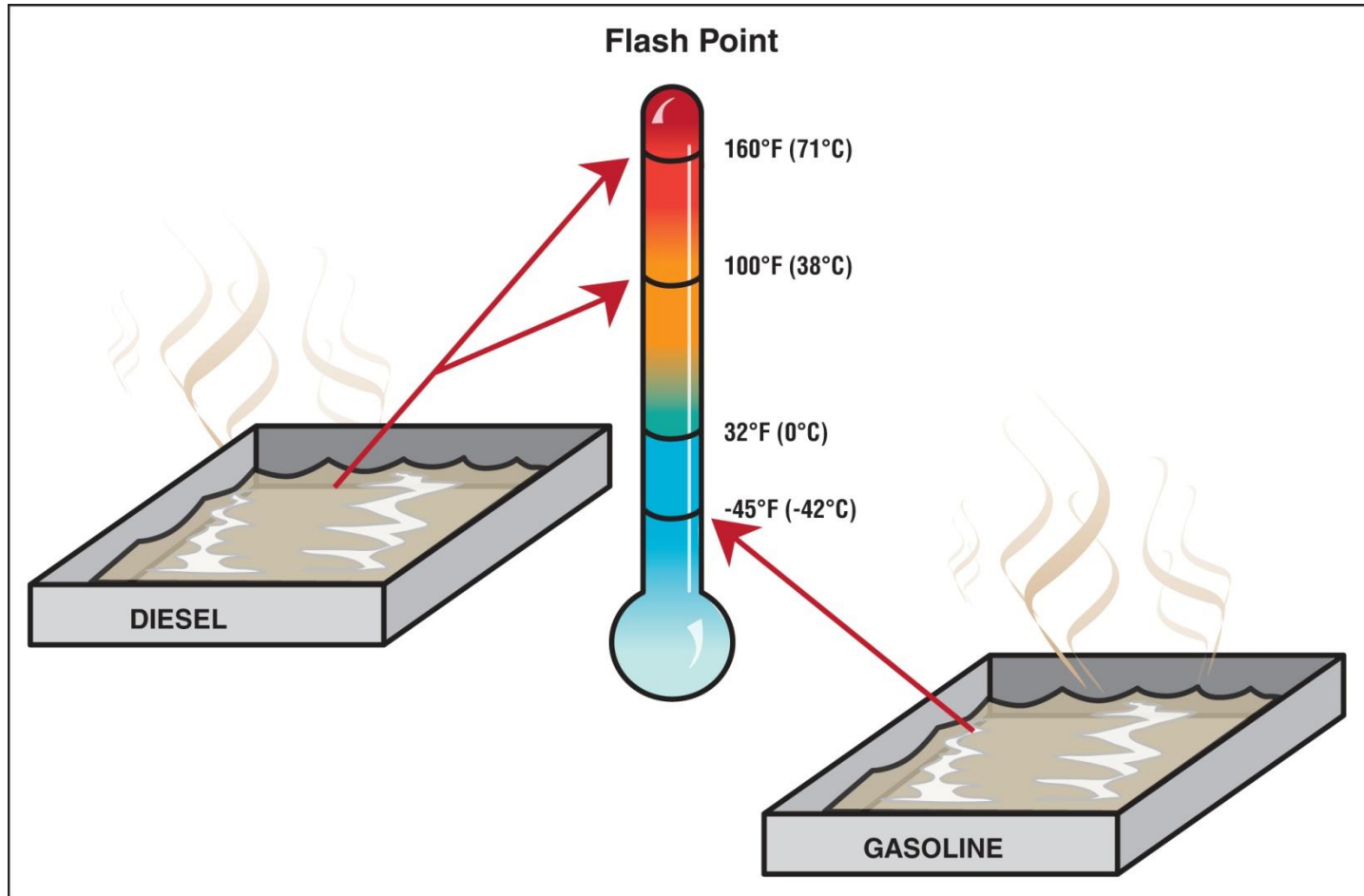
Learning Objective 2

Discuss the flammability of various hazardous materials.

Flammability depends on three properties.



Flash point is the temperature at which there are sufficient vapors to ignite, but not sustain combustion.



DISCUSSION QUESTION

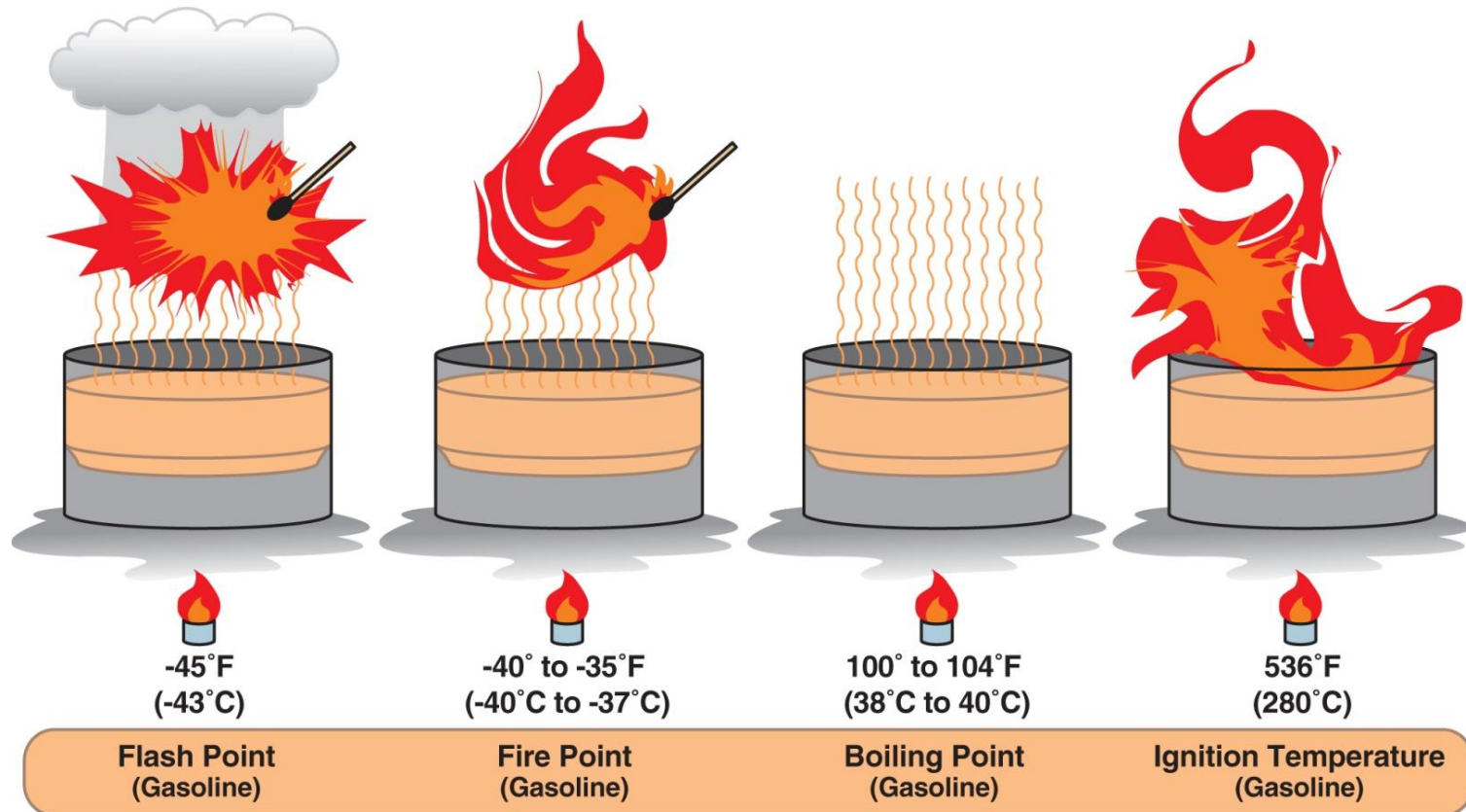


What is fire point?

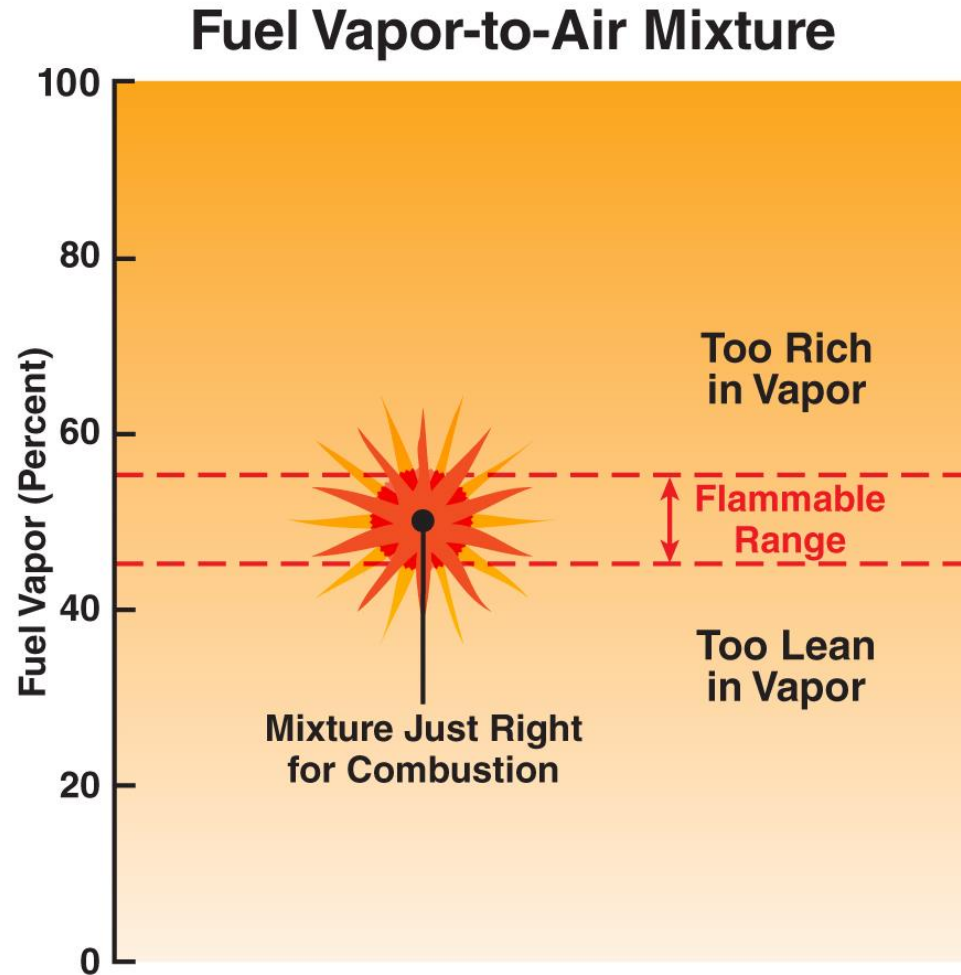
How is it different from flash point?

Autoignition temperature is the level to which the fuel in air must be heated to initiate self-sustained combustion.

Flammable Liquid Ignition



The flammable, explosive, or combustibile range helps to establish the lower and upper explosive limits.



REVIEW QUESTION



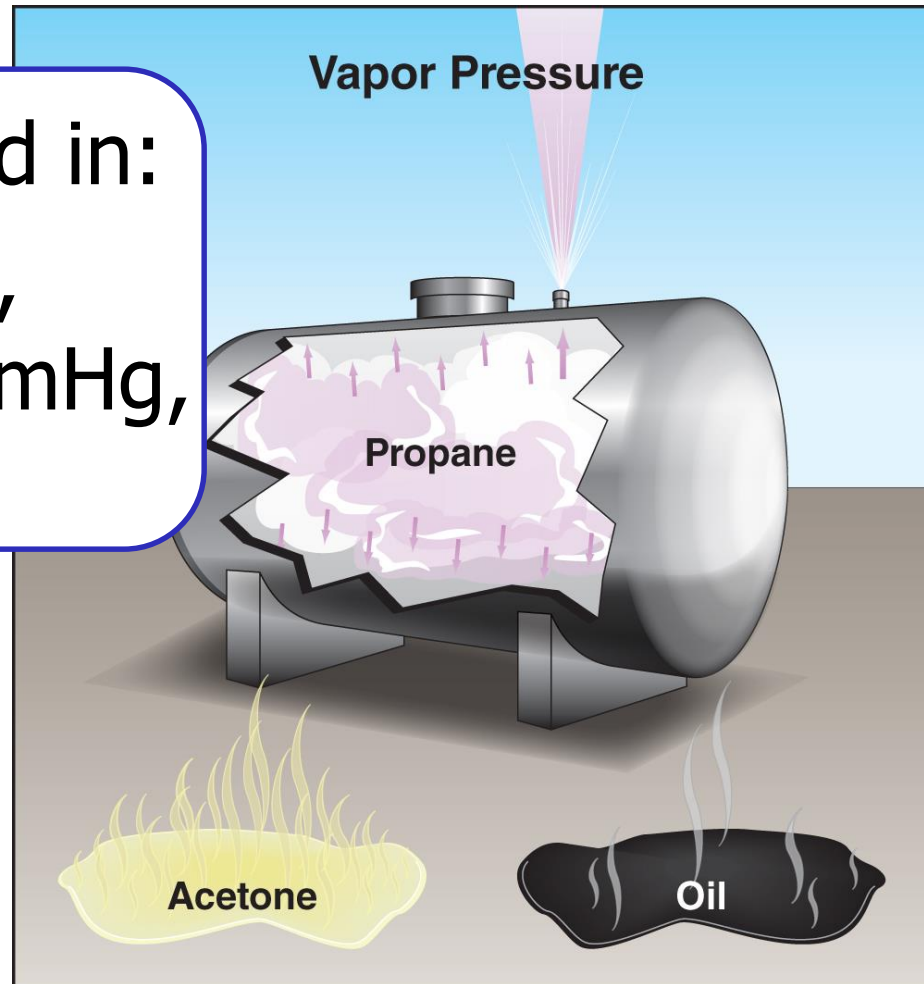
Define lower explosive limit (LEL) and upper explosive limit (UEL).

Learning Objective 3

Describe vapor pressure.

Vapor pressure is the pressure exerted by a saturated vapor above its own liquid in a closed container.

Expressed in:
psi, kPa,
bars, mmHg,
or atm



Learning Objective 4

Explain boiling point.

Boiling Point

- Temperature at which the vapor pressure of a liquid is equal to or greater than atmospheric pressure
- Usually expressed in degrees Fahrenheit (Celsius) at sea level air pressure

Boiling liquid expanding vapor explosion (BLEVE) can occur when liquid in a container is heated.



Internal vapor pressure exceeds vessel's ability to relieve pressure

Container fails, vapor is released, expands rapidly and ignites

REVIEW QUESTION



What is a BLEVE?

Learning Objective 5

Define melting point, freezing point, and sublimation.

Melting and freezing point definitions are based on normal atmospheric pressure.

Melting point

- Temperature at which a solid substance changes to a liquid state

Freezing point

- Temperature at which liquid becomes a solid

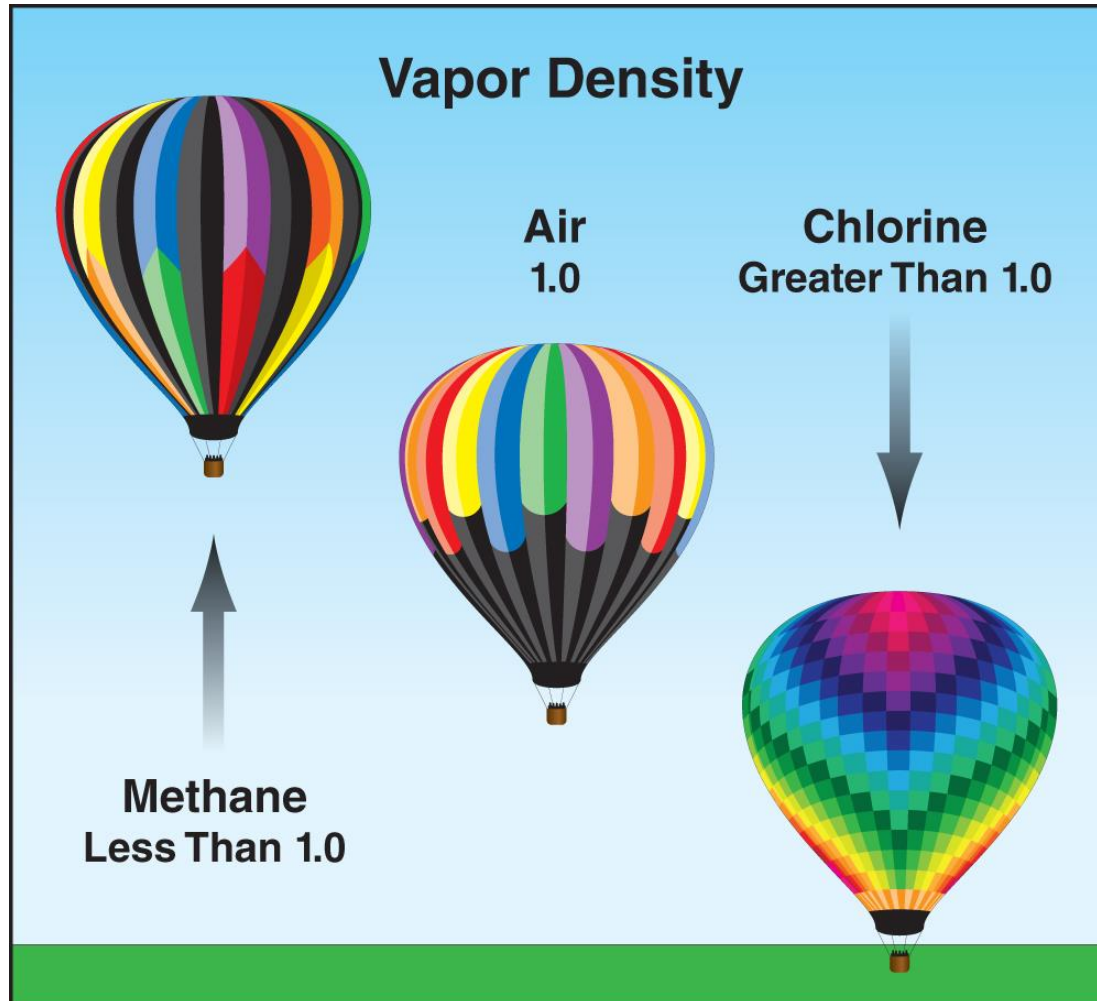
Sublimation is a change from solid to gas state without going into a liquid state.



Learning Objective 6

Describe vapor density.

Vapor density is the weight of gases compared to the same volume of air at similar temperature and pressure.



REVIEW QUESTION



What are some of the chemicals that have a vapor density lighter than air?

DISCUSSION QUESTION



How does knowing the vapor density of a material help during a hazardous materials incident?

Learning Objective 7

Define solubility and miscibility.

Solubility is useful in determining spill clean up methods and extinguishing agents.

Percentage of a material that will dissolve in water at ambient temperature

Affects if substances mixes with water

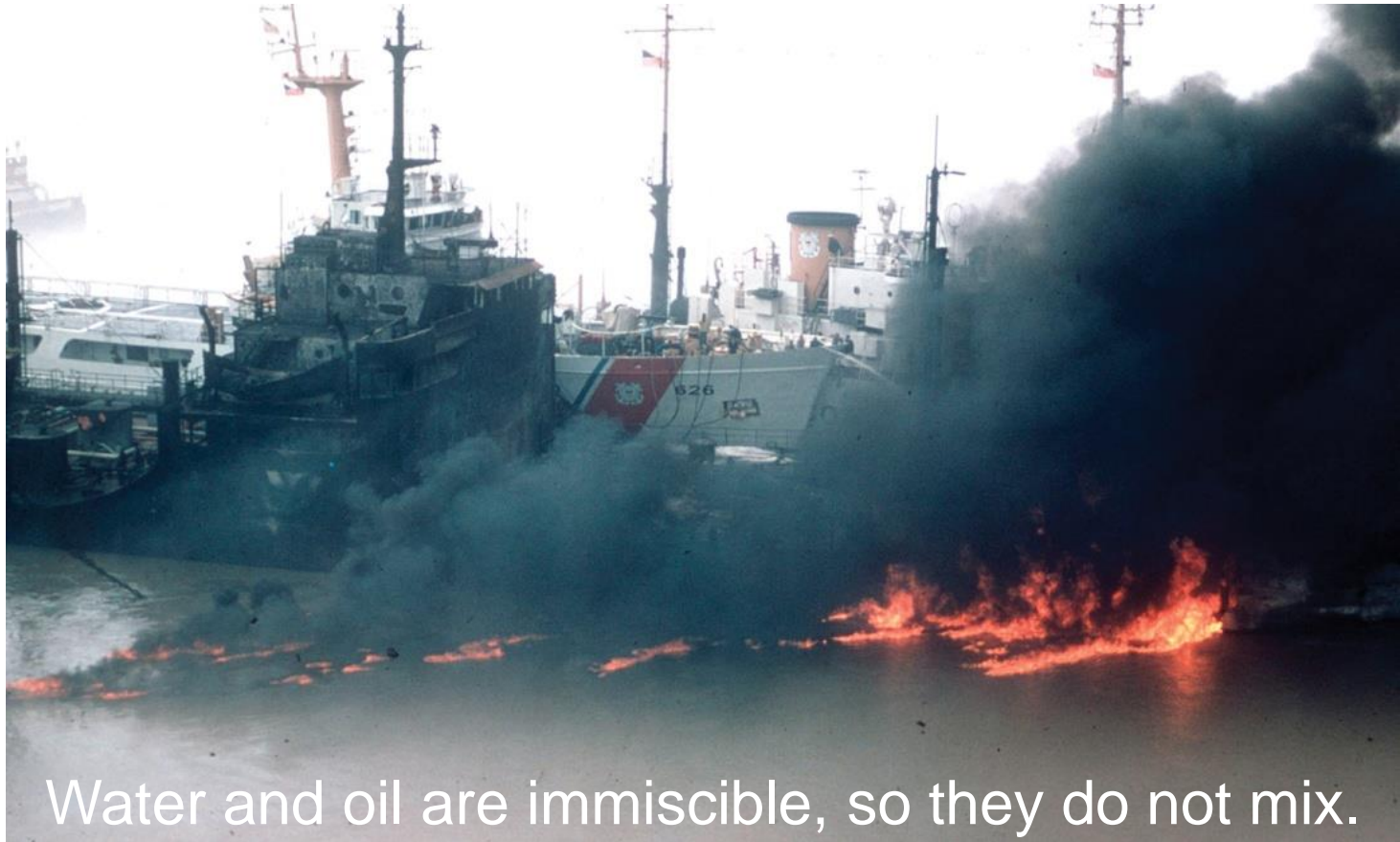
Important contributor in symptom development

DISCUSSION QUESTION



What are some examples of hydrocarbons and polar solvents?

Miscibility impacts how two or more gases or liquids mix with or dissolve into each other.



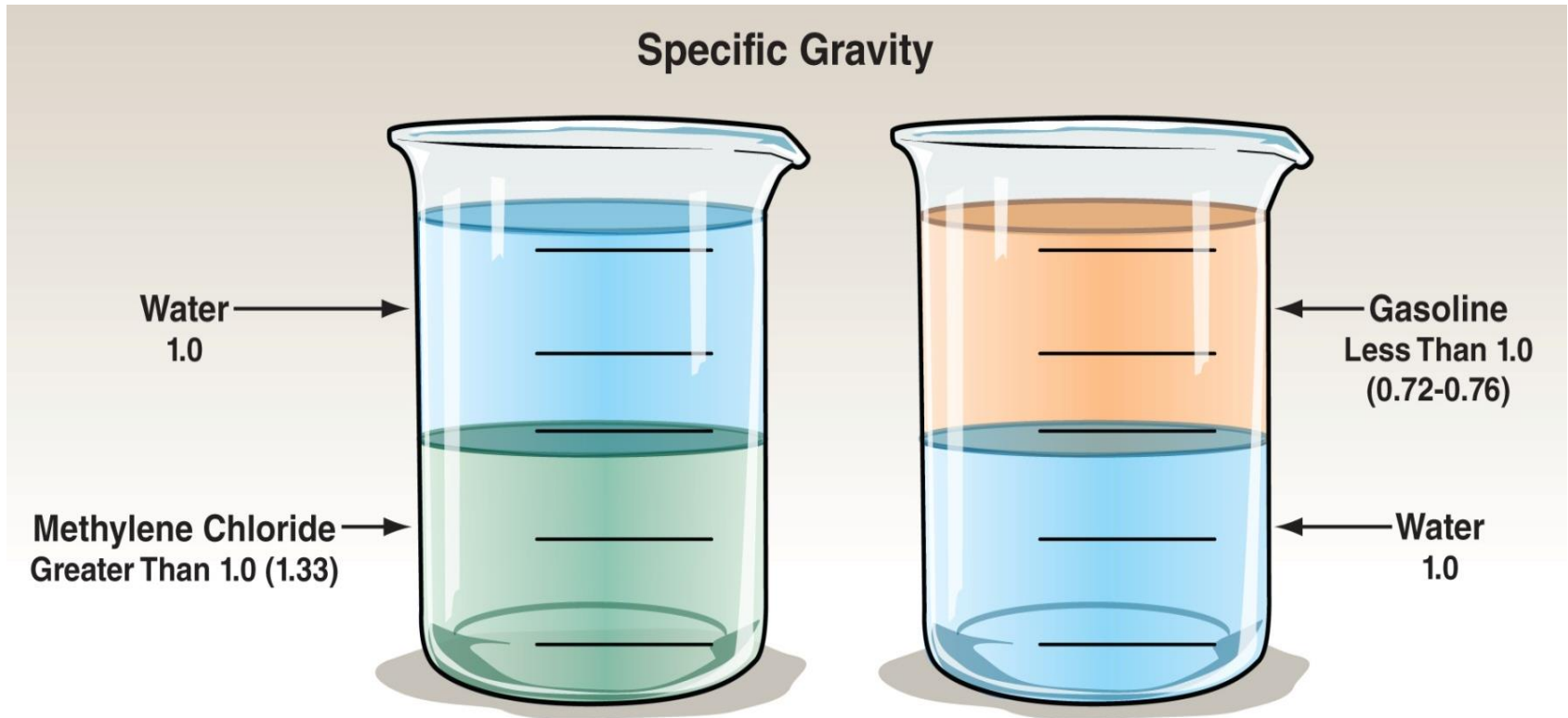
Water and oil are immiscible, so they do not mix.

Courtesy of U.S. Coast Guard

Learning Objective 8

Discuss specific gravity.

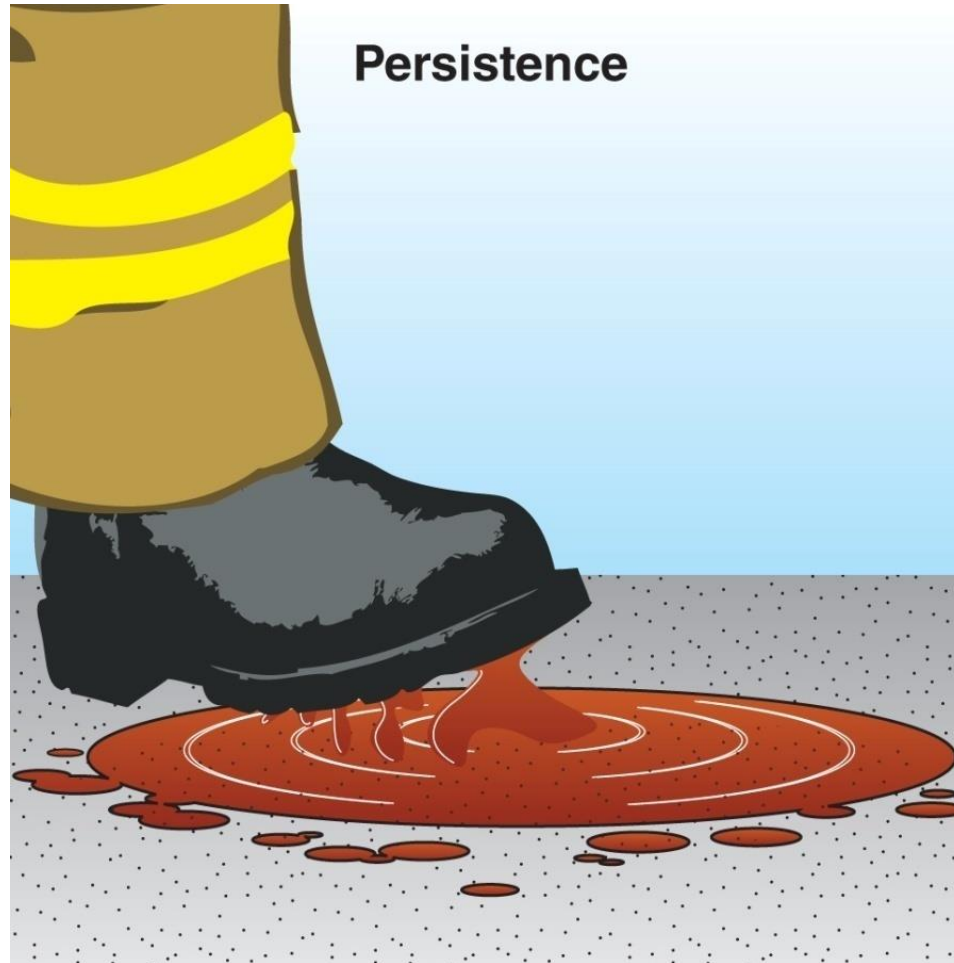
Specific gravity is directly influenced by solubility.



Learning Objective 9

Define persistence.

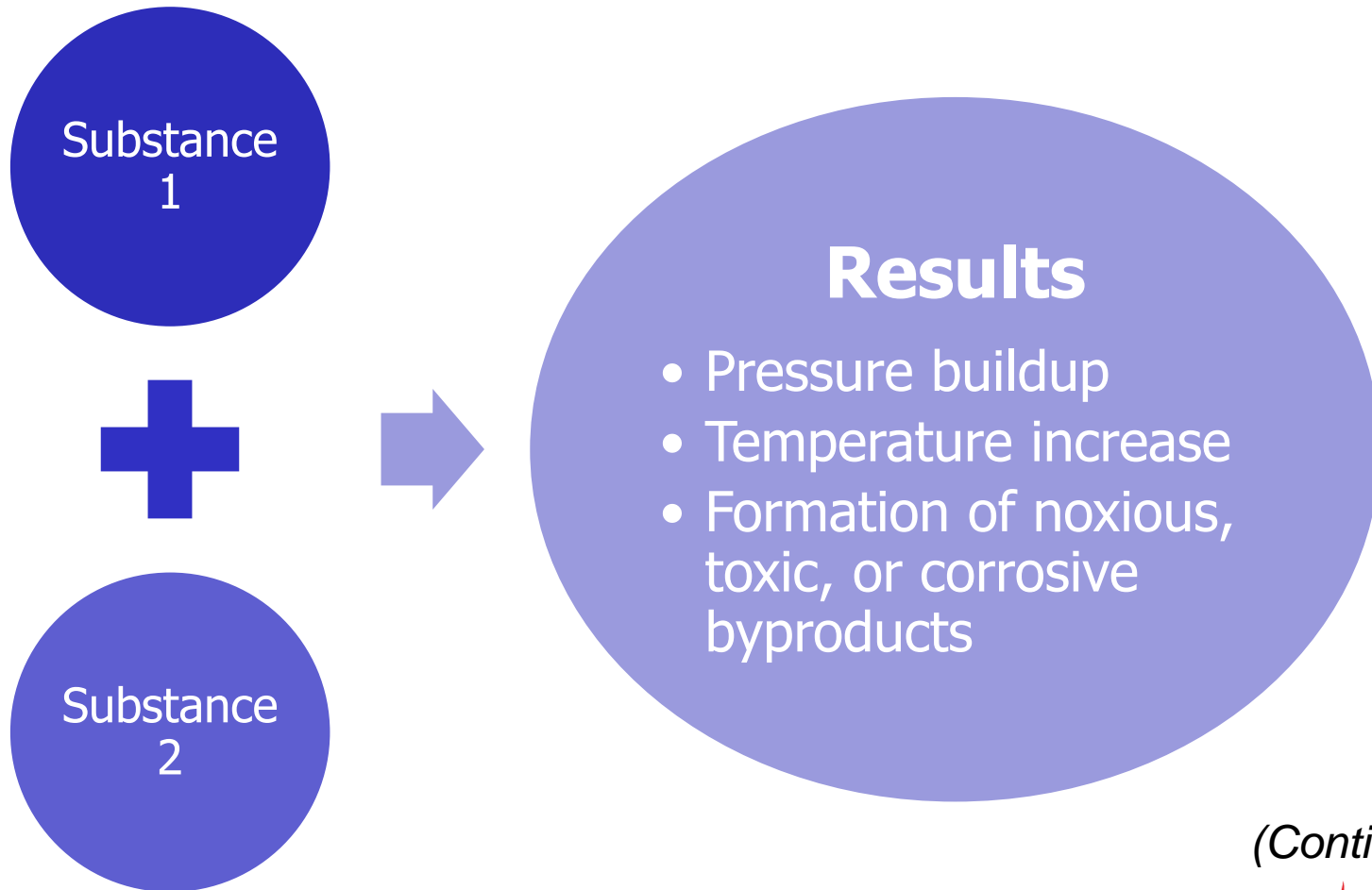
Persistence is a chemical's ability to remain in an environment.



Learning Objective 10

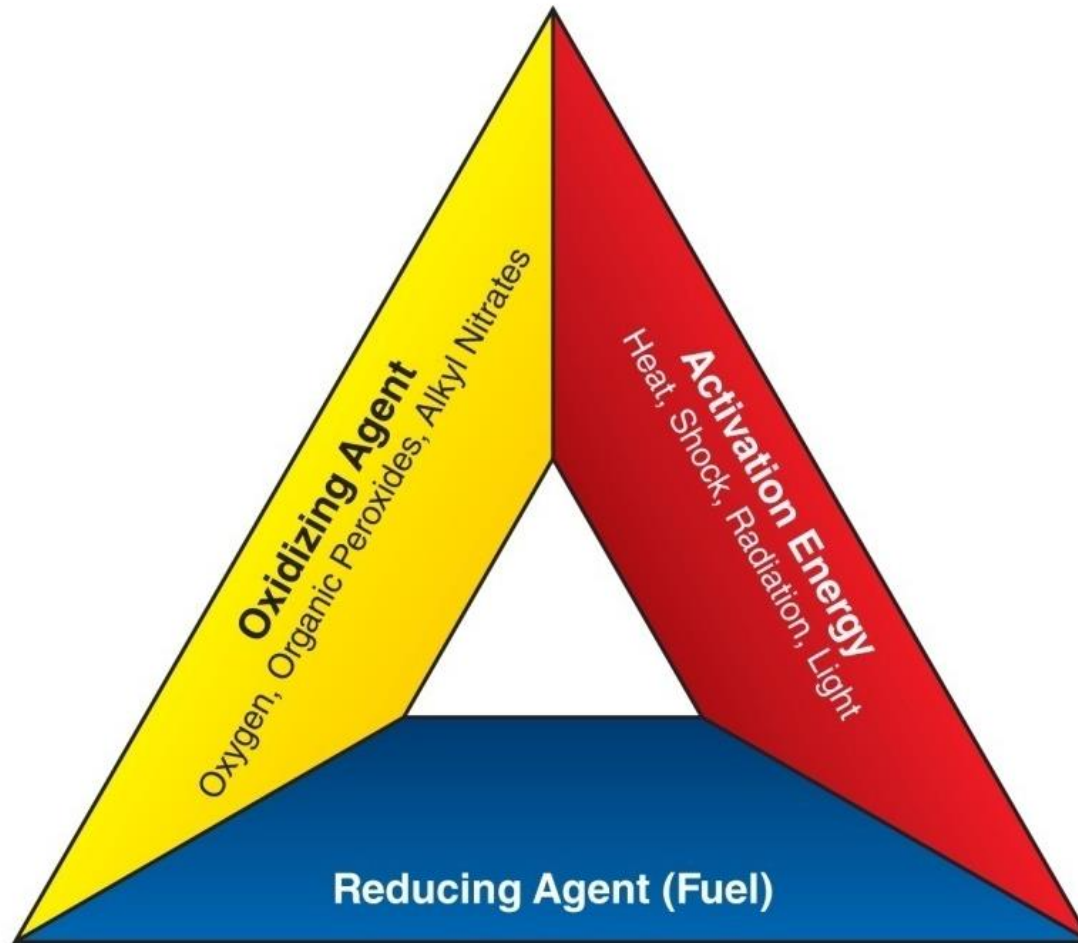
Define reactivity and describe the reactivity triangle.

Reactivity is the relative ability to undergo a chemical reaction with another material.



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The reactivity triangle explains the basic components of many chemical reactions.



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Reactivity can be effected by polymerization and inhibitors.

Polymerization

- Simple molecules combine to form long chain molecules
- May be marked with a *P* in the *ERG*

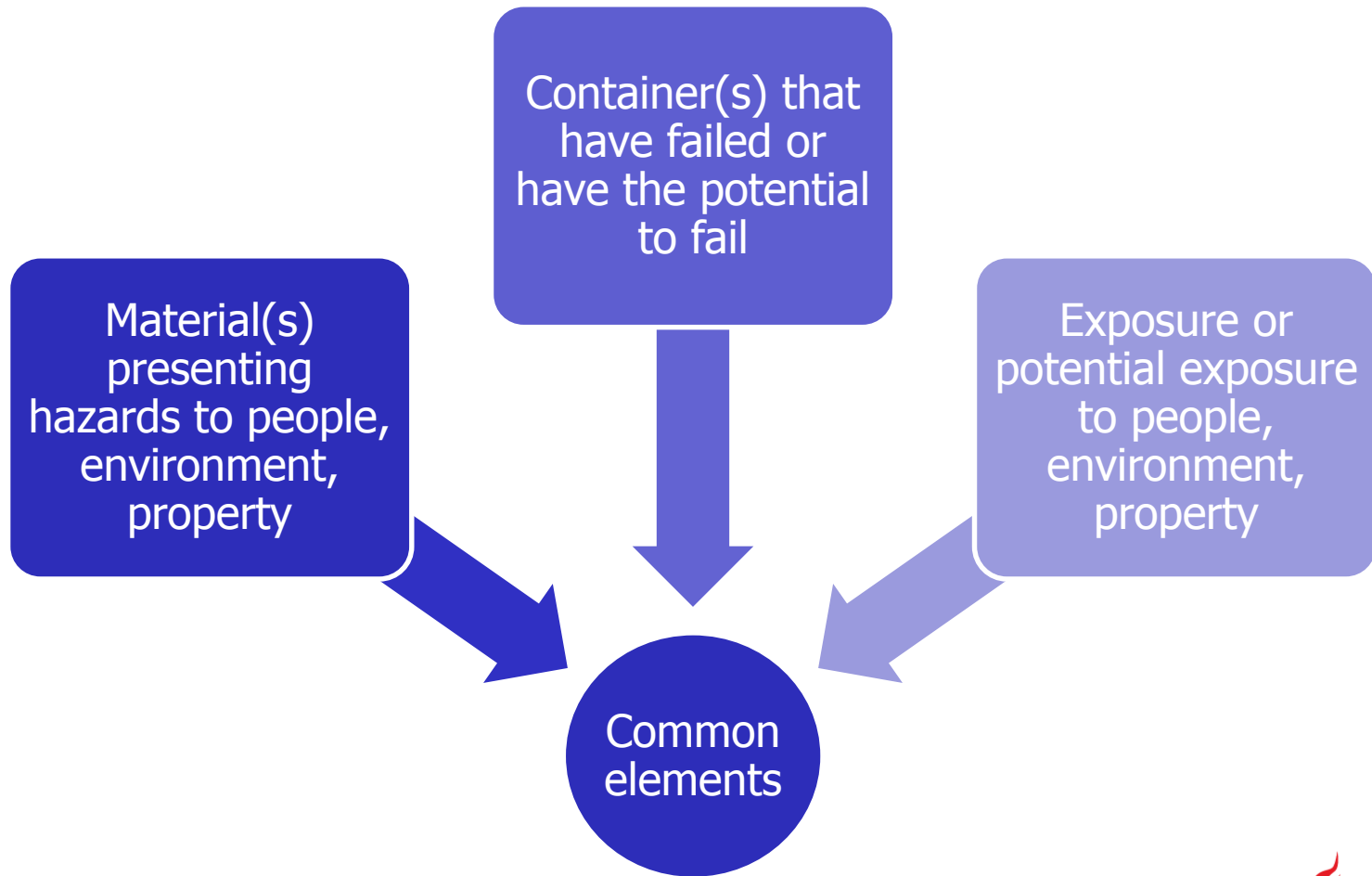
Inhibitors

- Materials added to products that easily polymerize to control or prevent undesired reaction
- May be time sensitive

Learning Objective 11

Describe the General Hazardous Materials Behavior Model (GEBMO).

GEBMO defines hazardous materials and explains common elements of haz mat incidents.



GEBMO describes the general sequence of events for hazardous materials incidents.

Stress

Breach

Release

**Dispersion/
Engulf**

**Exposure/
Contact**

Harm

Stress is stimulus causing strain, pressure, or deformity.



Thermal



Chemical



Mechanical



Breach occurs when a container is stressed beyond limits of recovery.



REVIEW QUESTION



What are the six portions of the GEBMO?

Types of Breaches

- Disintegration
- Runaway cracking
- Attachments open or break
- Puncture
- Split or tear
- Metal reduction



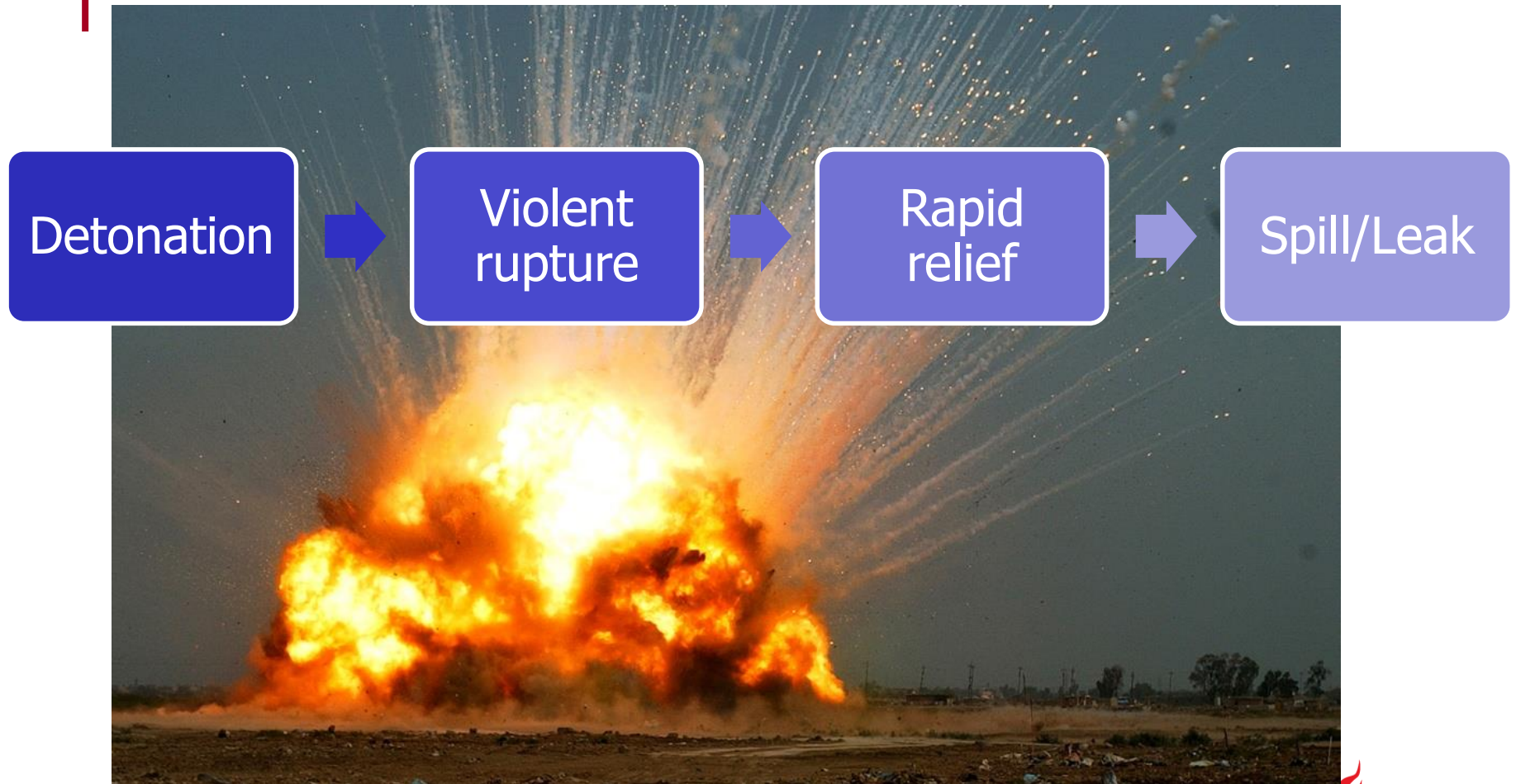
Courtesy of Phil Linder

REVIEW QUESTION



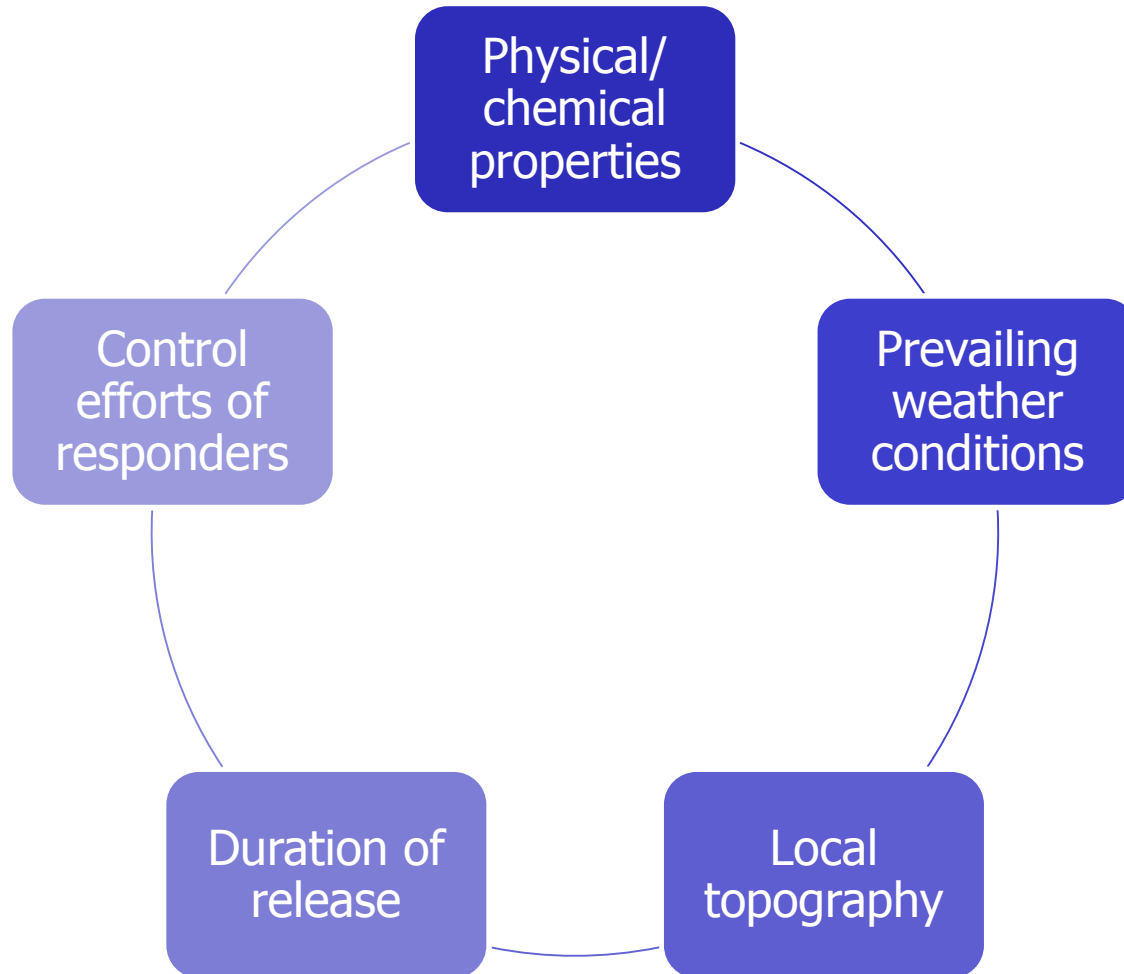
Describe several types of breaches.

Release can be product, energy, or parts of the container.



Courtesy of U.S. U.S. Army, photo by Sgt. Jabob H. Smith

The dispersion/engulf distribution occurs according to five factors.

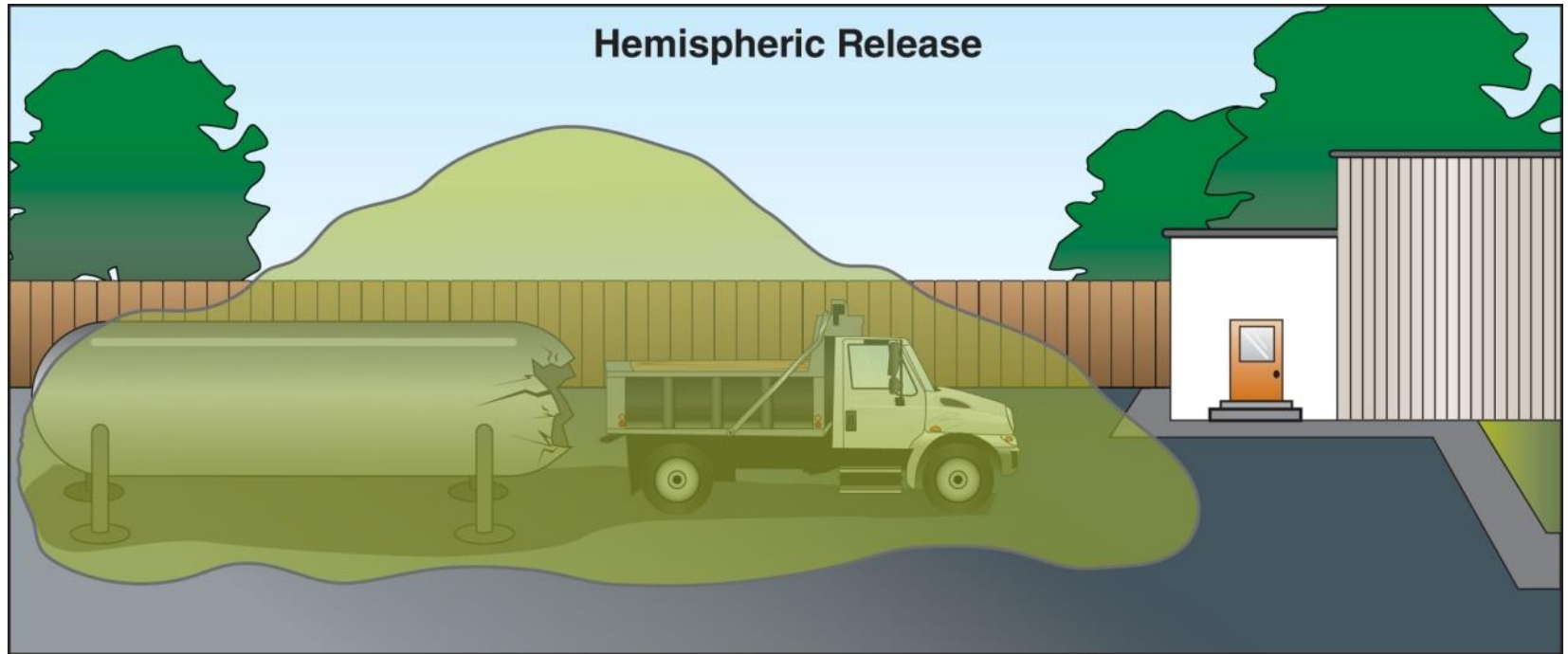


REVIEW QUESTION



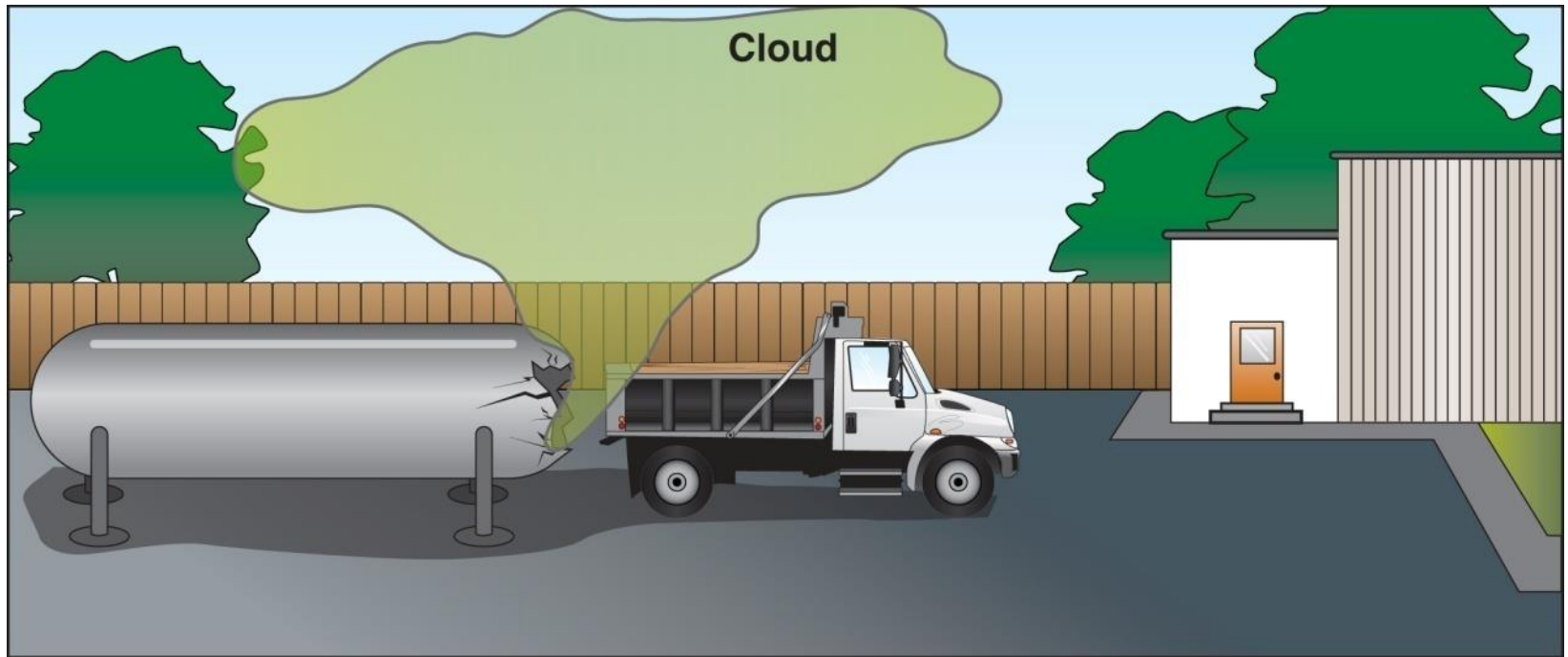
What are the classifications of releases?

A hemispheric dispersion pattern generally results from a rapid release.



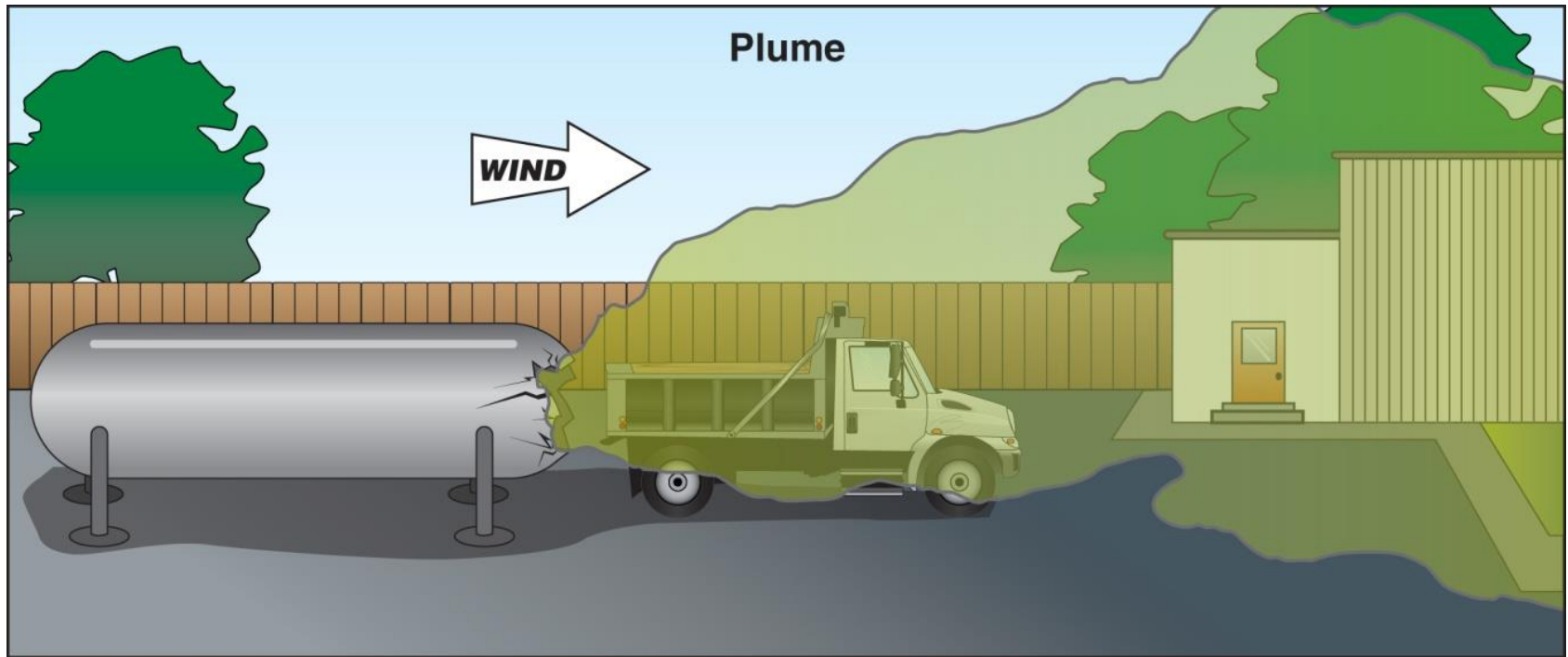
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A cloud dispersion pattern occurs when the material has collectively risen above the ground or water.



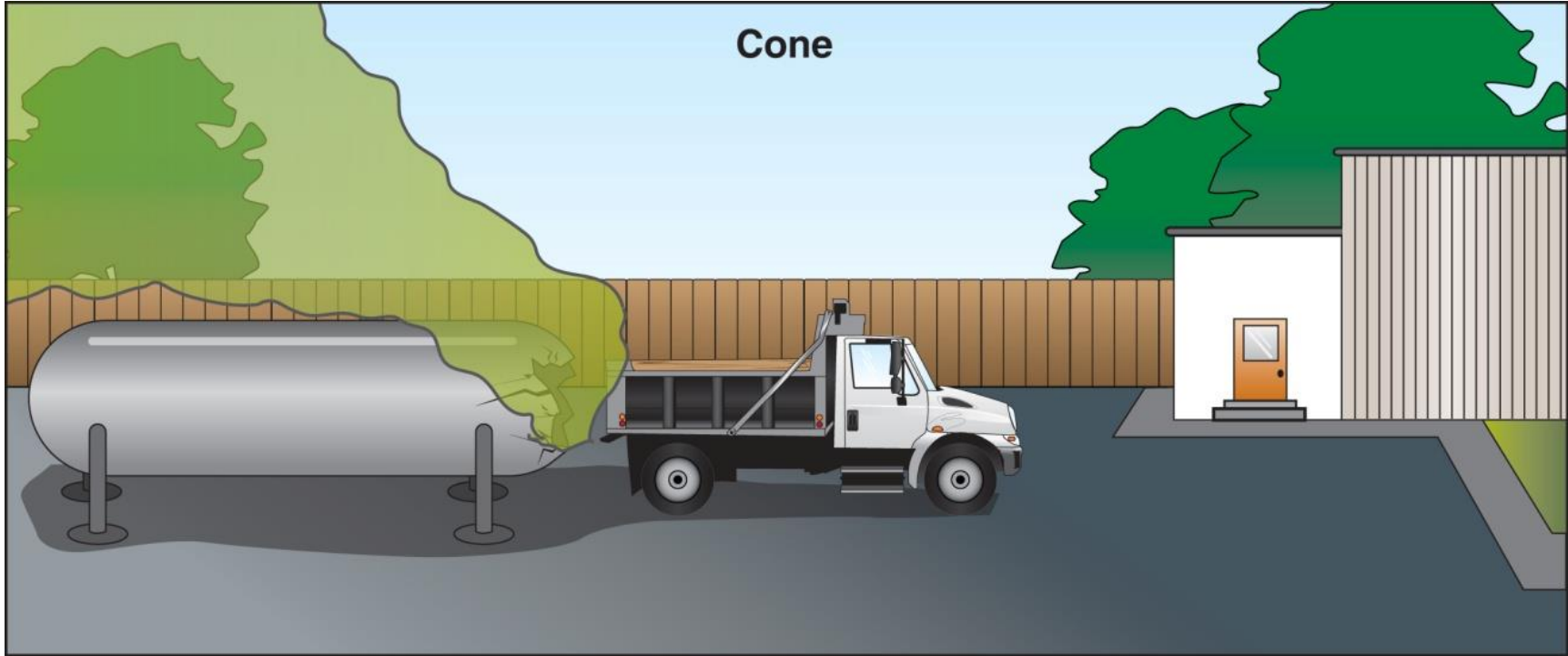
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The plume dispersion pattern is affected by vapor density, terrain, and wind speed/direction.



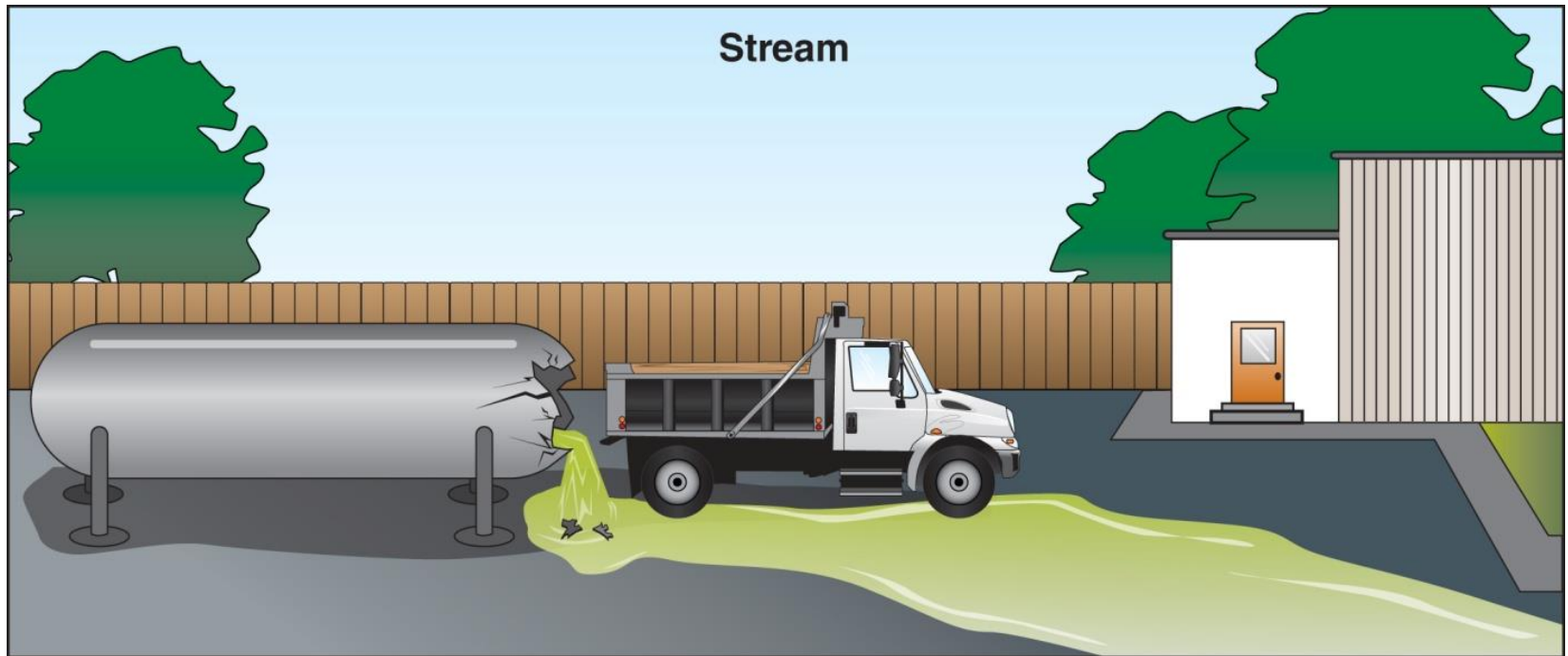
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The cone dispersion pattern has a wide base downrange of the breach.



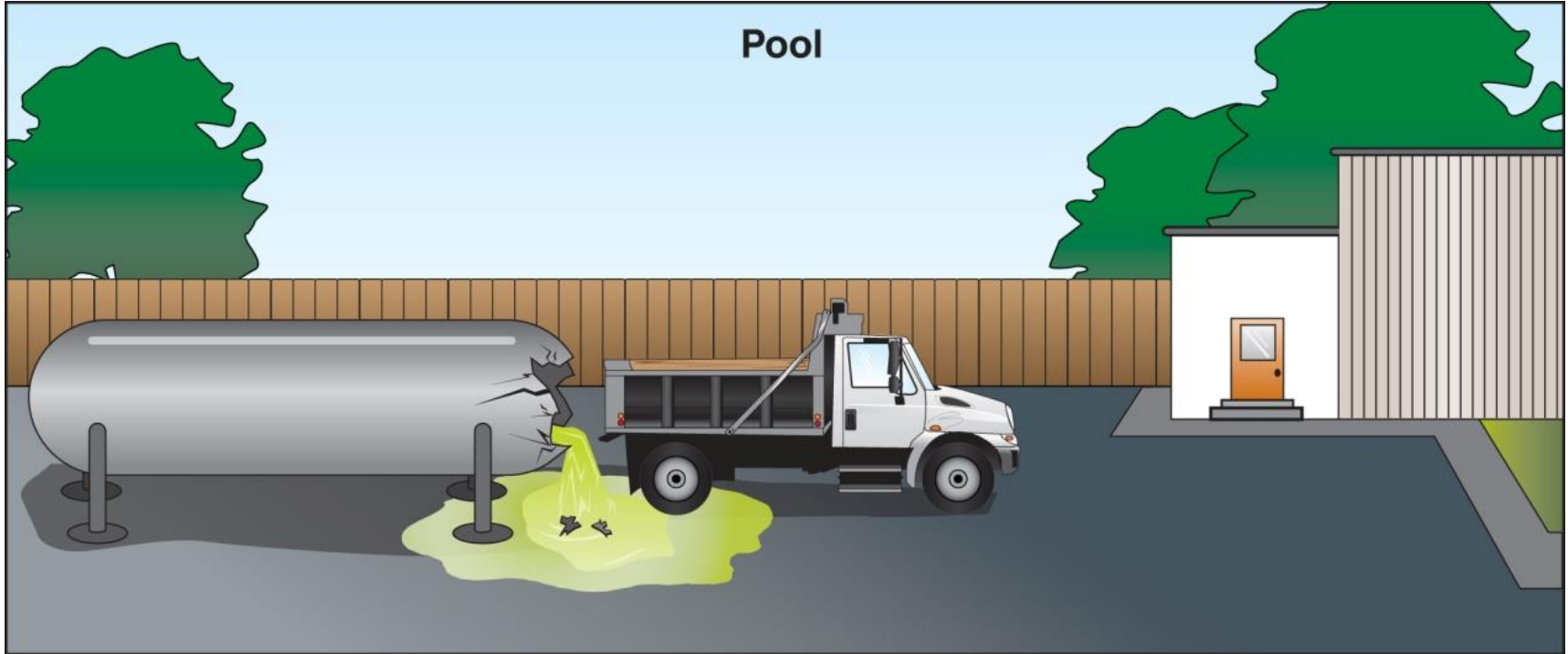
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The stream dispersion pattern is affected by gravity and topographical contours.



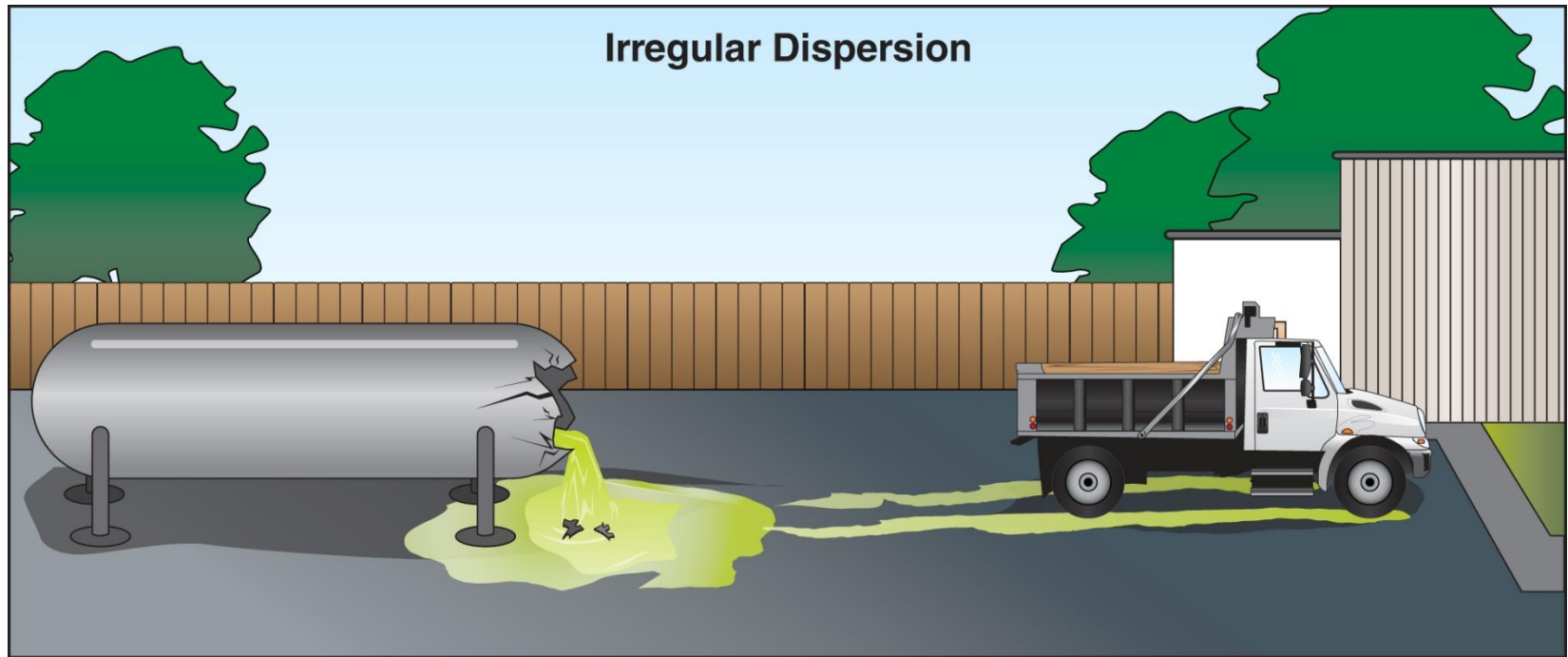
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The pool dispersion pattern is created by a three-dimensional, slow flowing liquid.



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Irregular dispersion patterns can result from contaminated vehicles or responders.

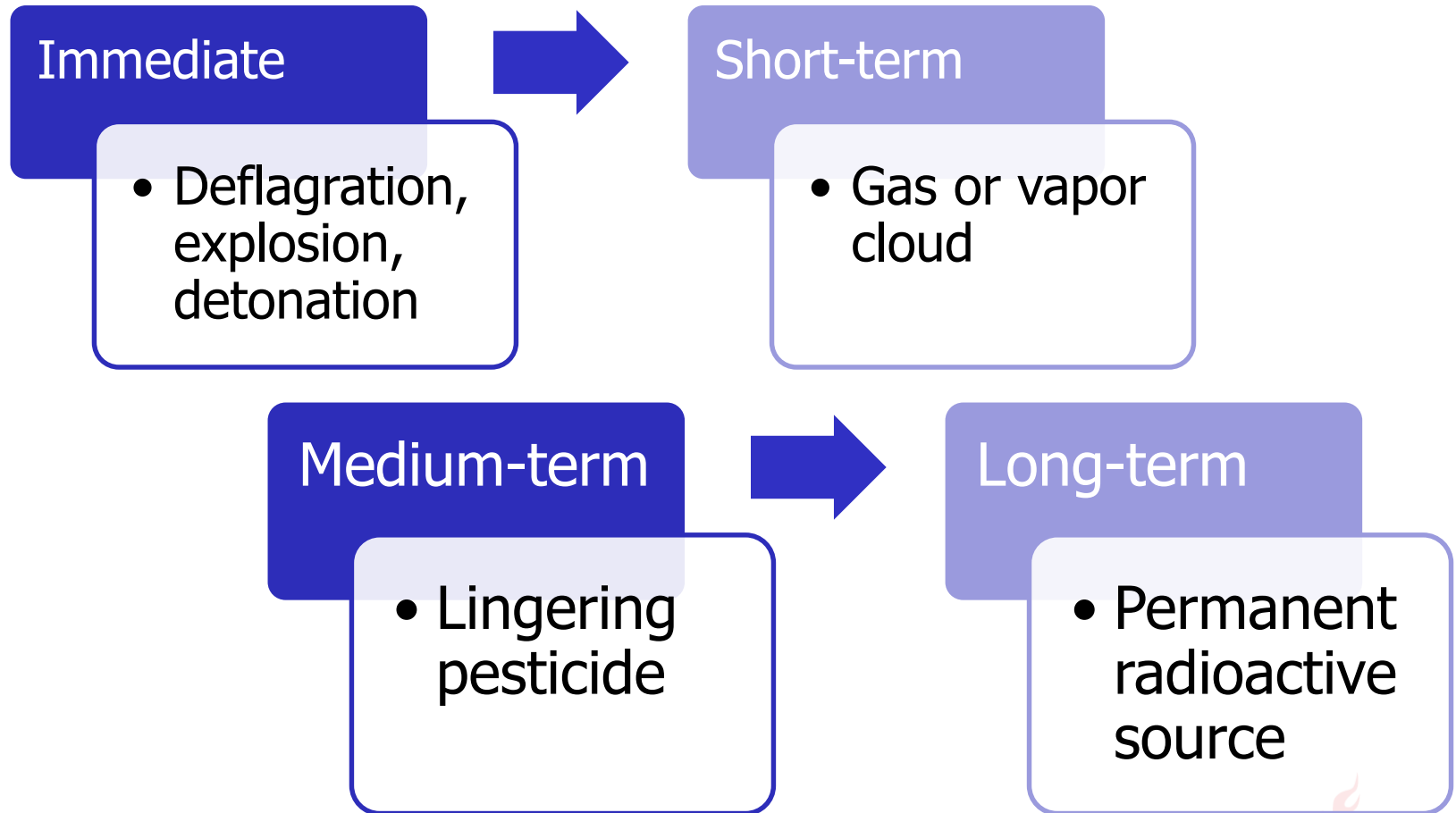


REVIEW QUESTION

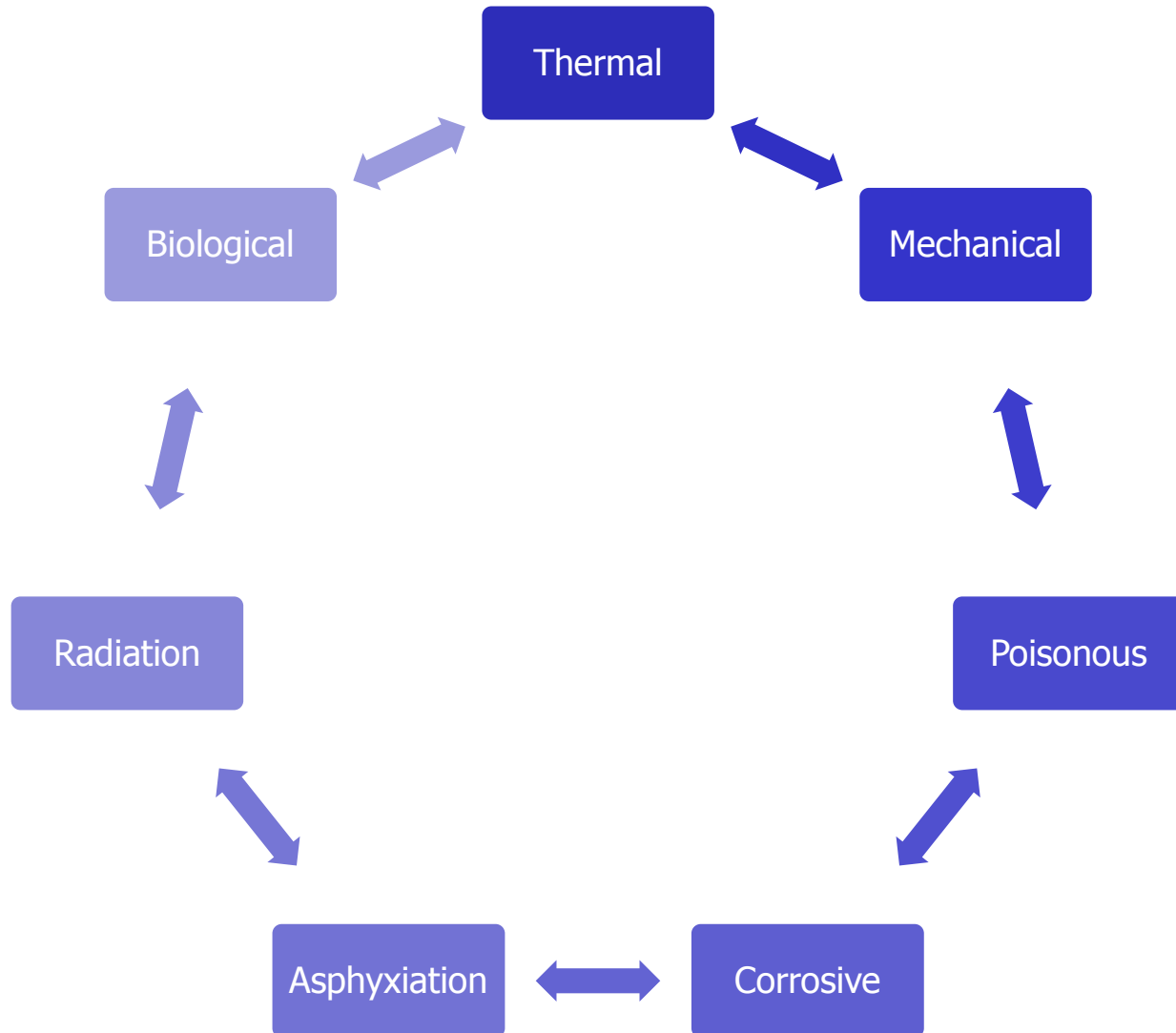


Describe each of the dispersion patterns.

Exposure/contact can effect people, environment, and property in a variety of timeframes.



Harm can be generated by a variety of health and physical hazards.



REVIEW QUESTION



What types of exposures should be considered in hazard and risk assessment?

Summary

- First responders need the ability to predict how a hazardous material will behave when it escapes its container.
- The behavior is often determined by the material's physical properties.