Chapter 3

Fire Dynamics: Chemistry and Physics

Section A: True/False

Directions: Write True or False on the blanks provided; if False, write the correct statement on the lines provided.

1. _____ Fuels must be in a gaseous state to burn. (58)

2. _____ The autoignition temperature of a substance is always lower than its piloted ignition temperature. (59)

3. _____ Gases always move from areas of lower pressure to areas of higher pressure. (61)

4. _____ Heat always transfers from warmer objects to cooler objects because heated materials naturally return to a state of thermal equilibrium. (65)

5. _____ Two different fuels may release different amounts of heat depending on their chemical makeup. (69)

6. _____ Flash point is the minimum temperature at which a liquid gives off sufficient vapors to ignite and sustain combustion. (72)

7. _____ There may be multiple flow paths in a compartment. (82)

8. _____ Rollover is always followed by flashover. (86)

_____

_____

9. _____ Different compartments in a structure may have fires in different stages of development. (90)

_____

_____

10. _____ Wind has very little impact on how fire develops in a structure. (91)

_____

_____

Section B: Fill in the Blank

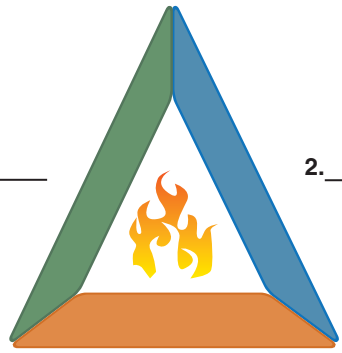
Directions: Write the correct answer on the blanks provided.

1. When plastic is heated and it melts into a liquid, this is an example of a _____ change. (54)
2. When two substances move against one another and generate heat, _____ energy is produced. (64)
3. Synthetic materials are made from petroleum products and have a _____ heat of combustion than wood. (70)
4. A solid fuel with a _____ surface-to-mass ratio will pyrolize faster than a solid fuel with a _____ surface-to-mass ratio. (73)
5. At normal ambient temperatures, materials can ignite and burn at oxygen concentrations as low as _____ percent. (75)
6. A _____-limited fire has sufficient oxygen to burn and will continue burning as long as it can reach more fuel. (78)
7. In order for flashover to occur in a compartment there must be sufficient _____ and a sufficient _____. (86)

Section C: Picture Identification

Part I: Fire Triangle and Tetrahedron

Label the elements of the fire triangle and tetrahedron in the images below. (58)

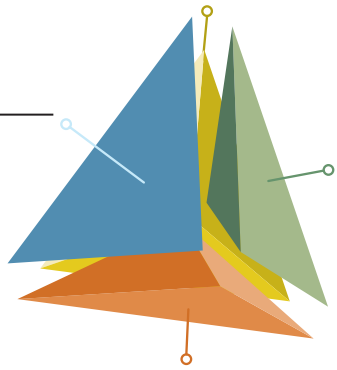


1. _____

2. _____

3. _____

4. _____



5. _____

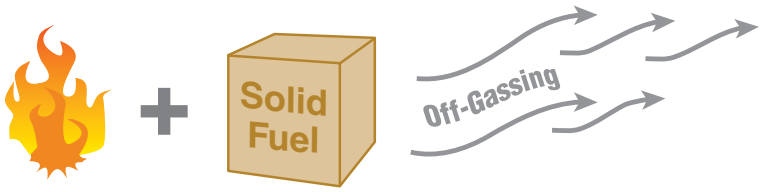
6. _____

7. _____

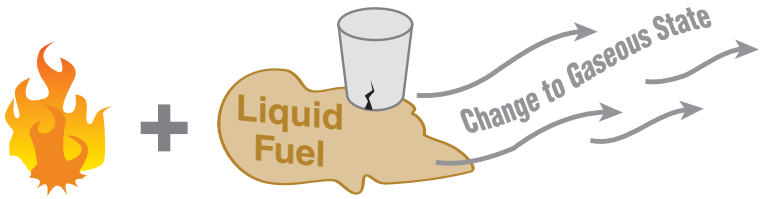
Part II: Ignition Process

Identify the process that is happening in each image below.

1. _____

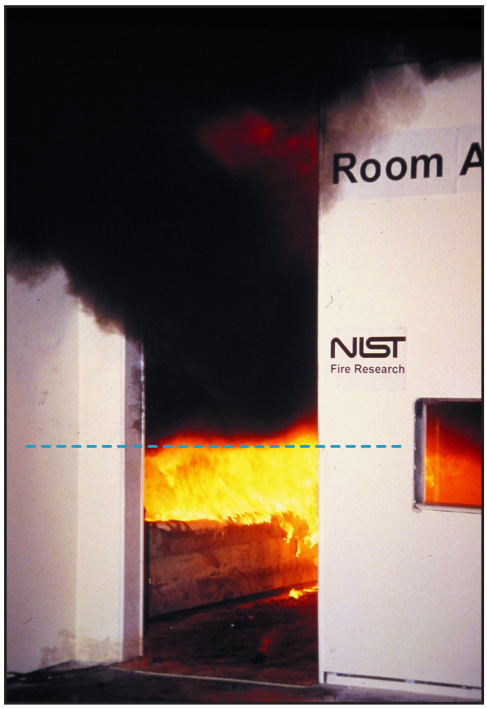


2. _____



Part III: Thermal Layering

Study the photograph, then answer the questions below. (82)



1. What does the dotted blue line in the photograph indicate?

_____

_____

_____

_____

2. What is happening above and below the dotted blue line?

_____

_____

_____

_____

Section D: Matching

Directions: Write the correct answers on the blanks provided.

Part I: Fire Science Terminology

Match the term with its appropriate description.

Terms:

A. Potential energy

B. Kinetic energy

C. Exothermic reaction

D. Endothermic reaction

E. Pyrolysis

F. Vaporization

G. Piloted ignition

H. Autoignition

I. Products of combustion

Descriptions:

_____ 1. Reaction that emits energy (57)

_____ 2. An external heat source is added to fuel and oxygen, starting the combustion reaction (58)

_____ 3. New substances that are created as a fuel burns (heat and smoke) (58)

_____ 4. Energy that a moving object possesses (57)

_____ 5. The physical change that happens when sufficient heat is applied to a liquid, causing it to change into a gas (58)

_____ 6. Reaction that absorbs energy (57)

_____ 7. Off-gassing when sufficient heat is applied to a solid material (58)

_____ 8. Starting the combustion process without addition of an external heat source (58)

_____ 9. Stored energy that an object can release in the future (56)

Part II: Heat Transfer

Match each description with its corresponding method of heat transfer.

Methods of Heat Transfer:

A. Conduction

B. Convection

C. Radiation

Descriptions:

_____ 1. Heat transferred through moving fluid (liquid or gas) (67)

_____ 2. Heat transferring from one solid to another solid (66)

_____ 3. Heat transmitted through electromagnetic waves (67)

Part III: Stages of Fire Development

Match each description with its corresponding stage of fire development. Each stage of fire development may be used more than once.

Stages of Fire Development:

A. Incipient

B. Growth

C Fully developed

D. Decay

Descriptions:

_____ 1. A hot gas layer begins to develop at the ceiling level. (80-87)

_____ 2. Rapid fire development usually happens in this stage. (80-87)

_____ 3. The fire has reached its peak heat release rate because of a lack of fuel or oxygen. (88)

_____ 4. The fire has not yet influenced any compartment beyond its original fuel package. (79)

_____ 5. Usually the final stage of fire development. (88)

_____ 6. The temperature in the compartment is slightly above ambient temperature. (79)

_____ 7. The fire has consumed all available fuel and heat release rate declines, but temperatures may remain high. (88)

Section E: Multiple Choice

Directions: Write the correct answers on the blanks provided.

_____ 1. When combustion occurs without producing visible smoke, soot, or ash, it is known as: (61)

A. pyrolysis.
B. vaporization.
C. complete combustion.
D. incomplete combustion.

_____ 2. The amount of heat that is transferred from one object to another can determined by calculating the object's: (62)

A. temperature.
B. dynamic energy.
C. potential energy.
D. heat release rate.

_____ 3. Which type of energy is the most common source of heat in combustion reactions? (63)

A. Chemical energy
B. Electrical energy
C. Radiation energy
D. Mechanical energy

_____ 4. If a structure on fire gives off enough heat to ignite a nearby exposure building, this is an example of: (67-68)

A. radiation.
B. convection.
C. thermal inertia.
D. thermal equilibrium.

_____ 5. What would happen if the fuel-to-air ratio was above the fuel's upper explosive (flammable) limit? (76)

A. The fuel would not burn.
B. The fuel would spontaneously combust.
C. The fuel would begin self-heating and eventually ignite.
D. The fuel would burn more efficiently than if it has a lower fuel-to-air ratio.

_____ 6. What process occurs when an extinguishing agent interferes with the chemical reaction in a fire and stops combustion? (77)

A. Oxidation
B. Pyrolysis
C. Incomplete combustion
D. Chemical flame inhibition

_____ 7. The space between the fresh air intake in a compartment and the exhaust outlet is known as the: (82)

A. origin.
B. flow path.
C. neutral plane.
D. exhaust corridor.

_____ 8. What occurs when all combustible materials and gases in a compartment ignite almost simultaneously? (85)

A. Rollover
B. Flashover
C. Fuel-limited decay
D. Fully-developed stage

_____ 9. If the fire in a structure grows large enough that it burns through the roof and causes a large hole, this is an example of: (90)

A. vaporization.
B. a wind-driven fire.
C. unplanned ventilation.
D. coordinated tactical ventilation.

Section F: Short Answer

Directions: Write the correct answers on the lines provided.

1. What three factors are required in order for self-heating to lead to spontaneous ignition? (63)

_____

_____

_____

_____

2. How does oxygen availability affect heat release rate? (74-75)

_____

_____

_____

3. What are two ways that gaseous fuels can be more dangerous than solid or liquid fuels? (70)

_____

_____

_____

_____

4. How can firefighters' actions affect the way a fire develops in a structure? (89-92)

_____

_____

_____

_____

Section G: Scenario

Directions: Answer the following questions based on the scenarios below.

Scenario 1 (78)

A campfire is left unattended and spreads to nearby grasslands. It burns uncontrolled for several days, causing widespread damage.

1. Is this fire fuel-limited or ventilation-limited?

_____

_____

_____

_____

Scenario 2 (78)

A fire starts in large trash container outside a warehouse. It continues to burn the materials in the container, but does not move to involve any exposures before it is extinguished.

1. Was this fire fuel-limited or ventilation-limited?

_____

_____

_____

_____

Scenario 3 (78-79)

A fire starts in the kitchen of a single-family home. It quickly spreads to involve other rooms. Flashover occurs before the firefighters arrive to begin suppression efforts.

1. Was this fire fuel-limited or ventilation-limited before the firefighters arrived?

_____

_____

_____

_____

Scenario 4 (86-87)

A fire is confined to one bedroom in a residential home. All doors and windows are intact. The fire burns uninterrupted for several minutes until the fire becomes fully developed. All available oxygen in the compartment is used by the fire, so the heat release rate begins to decline.

1. Predict what would happen if a firefighter or occupant were to open the bedroom door.

_____

_____

_____

_____