Review for Unit Test #3: Fire Emergencies

1. What are the four components of the fire tetrahedron?

   - **oxygen**
   - **fuel**
   - **heat and**
   - **a self-sustaining chemical reaction**

2. What are the four main factors that affect the rate of a chemical reaction?

   - **temperature**
   - **surface area**
   - **concentration of reactants**
   - **chemical reactivity of reactants**

3. Heat is both a requirement for, and a product of, fire. Explain.

   - **heat is required to pyrolyze solid fuels and vapourize liquid fuels, converting them to the gas state so that they can burn**
   - **heat is also required for ignition, to get the particles of fuel and oxygen moving fast enough that they will collide with enough force to ignite and catch on fire**
   - **heat is a product of fire because it gives off energy in the form of heat and light**
   - **when fires give off heat, this is the source of energy to pyrolyze, vapourize and ignite the fuels so that the fire will continue to burn (is self-sustaining)**

4. What are the five types of energy that can be used to ignite a fire? Give an example for each.

Type of Energy	Example
chemical energy	• phosphorus on a match head reacts with air to produce heat • oily rags slowly oxidize and produce heat that ignites the rags
electrical energy	• static electricity at the gas pumps can ignite gasoline vapours • spark plugs in a gasoline engine ignite the fuel in the pistons
mechanical energy	• friction creates heat when you strike a match, igniting phosphorus in the match head • compression of diesel fuel in the pistons of a diesel engine ignites diesel vapours
nuclear energy	• the sun produces energy by fusion reactions (joining atoms) • nuclear reactors produce energy by fission reactions (splitting atoms)
light energy	• radiant energy from the sun travels to the Earth. If it is focused using a magnifying glass, it can ignite fuels

5. Explain how oily rags or a big pile of wood chips can "spontaneously" ignite.

   - **the oil on the rags slowly reacts with oxygen in the air, and this generates heat**
   - **if the rags are in a pile, the heat cannot dissipate, so gradually the oil warms up**
   - **if it gets hot enough, the oil reaches its auto-ignition temperature and the rags catch on fire**

6. What causes many fires at gas stations? Why is this more common in women than in men?

   - **many fires at gas stations are ignited by sparks of static electricity**
   - **when people get into and out of their car, the friction of their clothes rubbing against the car seat builds up a static charge on their clothing**
   - **when they touch the nozzle to remove it from the car, the static charge jumps to the car as a spark, which can be 12,000 – 20,000 V and ignites gasoline vapours around the nozzle**
   - **this is more common in women because they get into and out of their car more often while the car is filling, to check their kids, their make-up, their cell phone etc**

7. Put a check-mark beside the substances which are oxidizing agents:

√ bromine	___ potassium chloride	√ oxygen gas	√ zinc phosphite
___ propane	√ hydrogen peroxide	√ magnesium chlorate	___ acetylene

8. How can you recognize many oxidizing agents from their names? **they end in "ate" or "ite"**

9. The chemical name for bleach is sodium hypochlorite. Is bleach an oxidizing agent? **yes, it ends in "ite"**

10. Give two examples of places where the air may be oxygen enriched.
    - **in a hospital or long term care facility where people are on oxygen**
    - **in a lab where they use compressed gases or oxidizing agents**
    - **in a factory or industry where compressed oxygen or oxidizing agents are used**

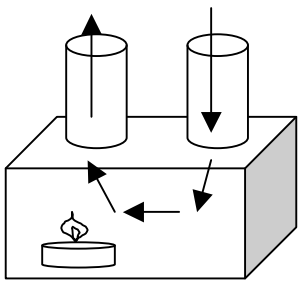
11. What characteristics are used to distinguish between superficial (first degree), partial thickness (second degree) and full thickness (third degree) burns?
    - **first degree (superficial) burns have redness and swelling, but no blistering**
    - **second degree (partial thickness) have redness, swelling and blistering**
    - **third degree (full thickness) burns have redness, swelling, blistering and charring (blackening) of the tissue. You will see black areas and may see exposed muscle**

12. Explain the difference between complete and incomplete combustion. What causes incomplete combustion? What do you see when combustion is incomplete?
    - **complete combustion occurs when there is plenty of air (oxygen) so the fuel burns cleanly producing a bright blue or yellow flame, very little soot and light coloured smoke**
    - **incomplete combustion occurs when there is limited airflow and inadequate oxygen, so the fuel does not burn cleanly. The flame is a dark orange colour and there is a great deal of black smoke and soot**

13. List two toxic (poisonous) gases that are produced by incomplete combustion.
    - **carbon monoxide (which is both toxic and flammable)**
    - **hydrogen cyanide**
    - **nitrogen oxides**
    - **acrolein**
    - **phosgene gas ($COCl_2$) may be created but only if a source of chlorine is present**

14. List three powders or dusts that are frequent causes of explosions.
    - **metal dusts, especially of the pyrophoric metals such as magnesium**
    - **flour and milk powder**
    - **carbon or graphite dust**
    - **sawdust**
    - **powders used in manufacturing drugs**
    - **powders used in manufacturing plastics**

15. Draw in the direction that you saw the smoke move during the smoke chimney experiment. Clearly explain WHY the smoke moved in this way.



    - **the candle flame heats the air around it, the particles move faster**
    - **the faster moving particles hit each other harder and spread out**
    - **because the particles have spread out, they are less dense, so they rise**
    - **cool air is drawn toward the flame (entrained) to replace the hot air that rose**

16. Understand the three methods of heat transfer and give an example of each in a fire situation. Which method of heat transfer is most important in fire development?

a) **Conduction:**
- when a source of heat is applied to one part of a conductor, the particles absorb this heat and start to move faster. They bump into the particles around them and transfer some of the energy to these particles, so the surrounding particles move faster. In turn, these particles bump into their neighbours, transferring some energy to them. Gradually, the heat is transferred along the conductor as the particles collide with each other
- conduction is the only way that heat can be transferred through a solid
- in a fire, if there is a metal beam, wiring or plumbing, the heat from one part of a building can be transferred to another part of the building by conduction through the metal, spreading the fire

b) Convection:
- when heat is applied to a fluid (either a gas or liquid) the particles close to the source of heat start to move faster. As they move faster, they hit each other harder, spread out, become less dense and rise. Cooler, slower moving particles move into the space that the heated particles left, and this creates a convection current
- convection can take place in either gases or liquids, but not solids
- in a fire, convection carries heat to the surfaces above it which causes fuel on these surfaces to pyrolyze and burn. This is why fuels that are "tilted" or vertical burn faster than horizontal fuels
- also, convection carries the hottest gases to the highest point in a compartment fire, and thermal layering occurs because the gases will be arranged by temperature, with cooler temperature gases found lower in the room
- **convection is the most important method of heat transfer in the development of most fires**

c) Radiation
- radiation is when heat travels as waves of light through space and no particles are involved. For example, radiation carries the sun's energy through space (essentially a vacuum) to the earth
- radiation may transfer heat from a fire to articles and structures around the fire. If enough heat is absorbed by the surrounding material, it may ignite and cause the fire to spread

17. Describe the five stages of fire development in compartment fire. What is significant or important at each stage?

Stage of Fire Development	Significance of this Stage
Ignition	• the components of the fire tetrahedron come together and the fire starts • if a source of heat pyrolyzes and ignites a small amount of fuel, this is called piloted ignition • if the fuel reaches its auto-ignition temperature and spontaneously ignites, it is called non-piloted ignition
Growth	• the fire produces heat, which pyrolyzes additional fuel which then burns, producing more heat • as more heat is produced, more fuel pyrolyzes and burns, causing a chemical chain reaction and the fire gets larger, and spreads • hot gases from the fire rise as a plume by convection and collect in the highest regions of the compartment • these hot gases heat the surfaces around them by radiation, causing them to pyrolyze and produce additional flammable gases
Flashover	• just before flashover, small regions of the hot gases may be hot enough to ignite, so you may see small "licks" of flame called rollover • hot gases from the fire and heated surfaces reach their auto-ignition temperature (at least 483°C) and the whole room fills with flame

Fully Developed	• all combustible materials in the room are on fire • there is adequate oxygen, but it is gradually consumed
Decay	• the fuel and oxygen are gradually consumed, so the chemical reaction slows down and temperatures begin to drop • eventually, there is inadequate fuel or oxygen to sustain the fire, and it goes out

18. Describe the conditions that lead to backdraft. What triggers a backdraft?

- backdraft is caused when a fire burns in a confined space and hot combustible gases are produced by pyrolysis but there is inadequate oxygen for them to burn
- the hot gases accumulate and often reach their auto-ignition temperature, but can't burn because there is no oxygen
- backdraft is triggered when a source of oxygen is introduced (if someone opens a door or window). The oxygen causes the hot gases to instantly ignite, creating a huge fireball that blows out of the opening

19. How is pyrolysis different from vapourization? How are they the same?

Pyrolysis	**Vapourization**
• the conversion of solid fuel into combustible gases	• conversion of liquid fuel to its gas state
• it is a chemical change, new substances are produced	• it is a physical change, the same substances are present just their state has changed
• requires energy	• requires energy
• converts fuel to a gaseous form that can burn	• converts fuel to a gaseous form that can burn

20. What is meant by "explosive range"?

- explosive range is the range of concentrations of a gaseous fuel in air that is capable of igniting and burning
- it is between the LFL (lower flammable limit) and UFL (upper flammable limit)
- below the LFL, the fuel concentration is too lean to burn
- above the UFL, the fuel concentration is too rich to burn

21. What are three ways that people can be trapped or killed due to truss construction in a building?

- a trussed roof may collapse onto them, trapping and/or burning them
- a trussed floor may collapse beneath them, trapping them in a lower floor
- the collapse of a trussed floor or roof will weaken the whole building and the outside walls may collapse, falling onto people and killing them

22. How can you tell if a building is balloon construction or platform construction by how the fire spreads?

a) Balloon construction:

- if a building is balloon construction, the studs run all the way from the sill on the foundation up to the attic, allowing hot gases and fire to spread quickly from basement to roof by convection
- if you see fire that is burning straight up an outside wall with no interruption, the building is probably balloon construction

b) Platform construction:

- if a building is platform construction, the studs for the first floor extend only to the bottom of the second floor, and the second floor is built as a platform on top of the first floor
- the first floor studs stop at the second floor, so there is no continuous pathway from the foundation to the attic
- if you see a fire that is contained to one floor, and maybe shows flames or smoke where the floors are joined, the building is probably platform construction

23. Why do trussed roofs fail so quickly?
    - trussed roofs fail quickly because they are held together with metal gusset plates. When heated, the metal curls and deforms, so the gussets pull out of the wood and the roof collapses
    - also, trussed roofs are engineered using only 2 x 4s, so the lumber is much smaller in dimension and burns through more quickly than larger lumber used in stick construction

24. Know the type of material that is burning in these classes of fires:

Class of Fire	Nature of the Fuel that is Burning
Class A	ordinary combustibles such as wood, paper, plastic and furniture
Class B	flammable liquids and gases such as gasoline, solvents, grease, propane, natural gas
Class C	live electrical equipment
Class D	pyrophoric metals
Class K	cooking oils or fats (usually in commercial or industrial kitchens)

25. What are the danger(s) associated with each of the following types of construction?

Type of Construction	Danger(s) associated with this type of construction
Balloon construction	• fire spreads rapidly from the basement to the ceiling, look for extension of the fire to the floors above the original fire
Truss construction	• trussed floors quickly collapse below people, trapping them in lower floors • trussed roofs quickly collapse above people, trapping or burning them • when trusses collapse, they weaken the whole building and exterior calls may collapse onto people, trapping or burning them
Steel I beams	• steel beams conduct heat from the original fire to other places in the building, causing the fire to spread • steel beams expand when heated and may push out exterior walls, causing them to collapse onto people • steel beams may sag, twist or deform when heated, causing the structures they support to collapse
Engineered I beams	• these wooden beams are made of very thin wood and rapidly burn through, causing the floors that they support to collapse

26. A compressed water fire extinguisher should **NOT** be used on a Class **B, C, D or K** fires.

27. A carbon dioxide fire extinguisher is not effective on a Class **A** fire. **It may rekindle**.

28. What type of substance is used to extinguish a fire in valuable fuels such as art or important paper records?

- a "clean agent" fire extinguisher that contains an inert gas (eg. Halon)
- the gas interrupts the chemical reaction and leaves no residue

29. What are the four steps to follow when using a portable fire extinguisher?

- P: pull the pin
- A: aim the nozzle of the extinguisher low, at the base of the fire
- S: squeeze the handle or trigger
- S: sweep the nozzle back and forth to put out the fire

30. What are four situations in which you should NOT use a fire extinguisher?

- when the fire is partly hidden in a wall or ceiling
- when the fire is no longer contained to its original container or fuel
- when the fire is blocking your way out of the room or building
- when the fire is too hot for you to be able to get close enough to extinguish it
- when the flames are higher than your head
- when there is heavy black, toxic smoke and poor visibility

31. What are four fire or explosion hazards that may be found in modern cars?

- undeployed airbags and aircurtains
- seatbelt "tensioners" that are made with compressed gas cylinders
- hydraulic cylinders used to hold up trunks, hoods, hatchbacks and tailgates
- plastic gas tanks that can melt
- batteries, especially on hybrid vehicles
- alternative fuels such as compressed propane or natural gas
- pyrophoric metals such as magnesium used in wheels, engine blocks and steering columns

32. What are three specific things firefighters SHOULD do when fighting a vehicle fire?

- park the fire truck 30 – 50 m back, uphill and upwind from the fire
- use the truck to block traffic and keep crowds away
- approach the car from uphill and upwind, at a 45° angle to the bumper
- approach from the side of the car that is not on fire
- always approach with a charged hoseline
- always wear all PPE, especially SCBA
- constantly be aware of the risk of explosion from batteries, airbags, hydraulic cylinders
- when possible, disconnect the battery cables, disconnecting the negative terminal first
- splash water at an angle off the pavement to get up and under the hood or trunk

33. What are three specific things firefighters should NOT do when fighting a vehicle fire?

- do not stand in front of the bumpers
- do not go in without SCBA
- do not cut orange electrical cables on hybrid vehicles
- do not allow leaked gasoline to get into sewers or drains
- do not spray water on gasoline, it spreads the fire
- do not underestimate the danger of car fires!!

34. This picture shows a gasoline spill on the pavement. Give two (2) reasons why the flames are found well above the liquid gasoline.

- the flames are above the liquid because it is the gas vapours (not the liquid gasoline) that is on fire
- the vapours are on fire where they are in the flammable range. Directly above the spill, the vapours are too concentrated and too rich to burn. As the vapours rise above the gas spill, they mix with the air and form an explosive mixture that is in the flammable range- this is where you see the flames.