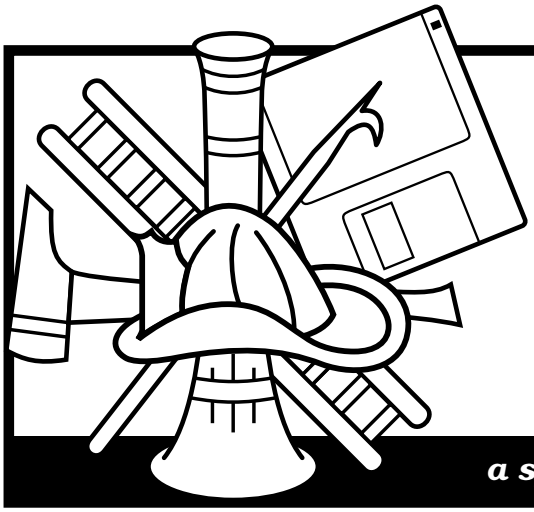


Preparing for the Final Exam

tips for dispelling test anxiety and prepping for a hazmat chemistry test

a special publication from Firebelle Productions

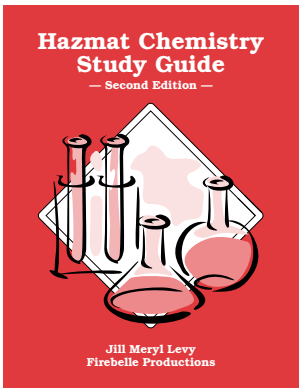
Introduction

This newsletter was inspired by a Hazmat Chemistry Prep Course that I developed years ago to help alleviate the anxiety many people feel prior to taking a hazmat chemistry class. The newsletter is divided into two sections:

- Dispelling Test Anxiety
- Recognizing the Concepts Behind the Chemistry

The first section first identifies what drives test questions, then provides some important tips to make studying for the exam easier. The second section cites several examples of how focusing on *concepts* more so than on *chemicals* can help you do well on an exam. You may be surprised at how easy it is to correctly answer many of the test questions even when you can't always put names to formulas or vice versa.

This newsletter contains the first chapter of the *Hazmat Chemistry Study Guide.*



Dispelling Test Anxiety

Hazmat chemistry classes don't need to be as intimidating as they frequently are. True, students are often hit with an overwhelming amount of information in a very short period, and studying for any exam can be stressful. However, no one should have nightmares about failing hazmat chemistry.

This newsletter contains the contents of the first chapter of the *Hazmat Chemistry Study Guide*. It may be the most important chapter in the book, because it helps students understand how to study the material in order to do well on the test.

The focus is on dispelling test anxiety and recognizing the concepts behind the chemistry.

Know What Drives the Test Questions

It helps to understand a little bit about the test writing process and what test writers contend with. Several factors influence what questions are used in the final exam:

- Regulations (federal, state, local, tribal). Various regulations dictate what training responders must receive and how they must perform in the field. If you've reviewed the regulations that apply to your area or agency, it can help you anticipate the material you'll be tested on.

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- Standards and recommended practices. The National Fire Protection Association (NFPA) *Hazardous Materials/Weapons of Mass Destruction Response Handbook* contains the entire texts of NFPA 472 and NFPA 473, along with explanations and background material. One of the best things you can do to prepare for any hazmat class is to review applicable sections of this NFPA publication before and during class. (Note: NFPA 472 and 473 have since been consolidated into NFPA 470, the Hazardous Materials/Weapons of Mass Destruction [WMD] Standard for Responders.)

- Special concerns. Test writers sometimes emphasize special concerns reflective of a given area or industry. For example, in an area with heavy rail transportation of hazardous materials, there are likely to be more test questions related to managing rail incidents and the products commonly shipped by rail than there would be in other parts of the country. As another example, classes taught specifically for the petroleum industry may be have tests that emphasize petroleum products more so than other chemicals.

- Test writer's own focus. Test writers may include questions relating to specific problems they've seen or experienced in the field. For example, they may write questions that drive home key points missed by responders killed in a tragic incident where things went terribly wrong.

Test questions are often based on regulations, standards, and recommended practices.

Let's look at a couple of examples to illustrate how the factors above can drive test questions. NFPA 470 identifies the competencies expected of hazmat responders. For instance, it lists a number of terms and indicates that the hazardous materials technician shall describe the terms and explain their significance in the risk assessment process. Let's take one of those terms and look at how it can be turned into a test question.

The NFPA *Hazardous Materials/Weapons of Mass Destruction Response Handbook* describes *expansion ratio* as the amount of gas produced by a given volume of liquid at a given temperature. For example, liquid propane has an expansion ratio of 270 to 1, while liquefied natural gas has an expansion ratio of 635 to 1. What makes this significant is that the greater the expansion ratio, the more gas is produced and the larger the endangered area becomes.

If NFPA 470 says hazmat technicians should be able to describe such terms, it's reasonable to expect a question that asks you to identify which of several definitions describes expansion ratio—your basic vocabulary question. However, a better question is one that tests if you recognize how expansion ratio affects risk. The example below lists four liquefied gases and their expansion ratios. If you remember that the higher the expansion ratio, the greater the risk, you can easily pick liquid hydrogen (a) as the correct answer.

> Which of the following will produce the most gas and endanger the largest area?
>
> a. Liquid Hydrogen (expansion ratio 848 to 1)
> b. Liquefied Natural Gas (expansion ratio 635 to 1)
> c. Liquid Nitrogen (expansion ratio 694 to 1)
> d. Liquid Propane (expansion ratio 270 to 1)

NFPA 470 identifies the competencies expected of hazmat responders. So it is reasonable for test writers to write questions that reflect those competencies.

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Let's take a different example now, one reflecting a test writer's desire to protect responders from suffering the same tragic fate experienced by firefighters who died battling fires involving ANFO (ammonium nitrate and fuel oil mixture). While not strictly a chemistry question, a question like this is very effective for reinforcing key concepts that matter most in the field. The correct answer is that no attempt should be made to fight a fire involving explosives (a).

According to the NFPA:

a. No attempt should be made to fight a fire involving explosives
b. Fires involving explosives should be handled from a distance of at least 1000 feet
c. Fires involving explosives should be handled from a distance of at least 2000 feet
d. Firefighters should wait for the initial explosion, then move in to extinguish a fire involving explosive materials

Test writers sometimes emphasize special concerns reflective of a given area or industry.

Pay Attention to Errors, Mistakes, and Misconceptions that Arise in Class

Some of the best test questions use common errors, mistakes, and misconceptions as distracters (wrong answers), because they differentiate between students who know the material and those who don't. If there's something that students seem to be struggling with in class or something the instructor identifies as being a difficult concept for students to grasp, that ought to be a blip on your radar screen. Let's look at one example:

What is generally the greatest risk associated with organic peroxides?

a. They are very toxic
b. They are strong oxidizers that will fuel a fire
c. The are flammable and unstable, similar to explosives
d. They are highly unpredictable

Some of the best test questions use common errors, mistakes, and misconceptions as distracters (wrong answers), because they differentiate between students who know the material and those who don't.

The correct answer is that organic peroxides are flammable and unstable, similar to explosives (answer c), because they contain both a fuel component and an oxidizer component in the same structure, just as explosives do. They are very sensitive to heat and friction. They're often very sensitive to contamination too.

Students who don't understand the significance of this frequently identify organic peroxides as strong oxidizers (answer b), in part, because of the Department of Transportation classification system in which oxidizers (Division 5.1) and organic peroxides (Division 5.2) used to have very similar placards. (The new Division 5.2 placards and labels, which are half red and half yellow, with a flame on top, are designed to more accurately reflect the hazards of organic peroxides.) However, the explosive potential represents a greater risk than the oxidizing potential with these materials. Can organic peroxides be very toxic (answer a)? Yes. Can they be unpredictable (answer d)? Yes … although it's probably more common that emergency responders fail to anticipate what should be very predictable behavior. So with these very plausible distracters, it's easy to see how students could choose a wrong answer.

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Use the Resources in Your Student Manual

Every student manual or textbook is different, but most contain tools to enhance learning:

- Sample test questions. Student manuals may contain multiple choice test questions similar to what you'll see on the final exam (similar to questions contained in the *Hazmat Chemistry Study Guide*). If not, ask your instructor to present some in class.

- Chapter review questions. Chapter review questions are often fill-in or short answer format. For example, you might find a question that asks you to identify which type of hydrocarbon derivative is known for its toxicity and wide flammable range. Or it may ask you to list the hazards generally associated with several hydrocarbon derivatives. This is more difficult than a multiple choice question, but it's very effective for helping students learn.

- Exercises and worksheets. A variety of things are possible with exercises and worksheets. You might be asked to do something relatively simple, like draw the structure of a compound. While this isn't something you're likely to have to do on your final exam, it's a great exercise to help you see how the atoms are bonded and help you count the individual elements. Another great activity is one that requires you to apply the information in a way that reflects what you would have to do in the real world, for instance, to look up the chemical and physical properties of a substance in at least three reference sources.

Most student manuals contain tools (sample test questions, chapter review questions, exercises, or worksheets) to enhance learning.

Ask the Instructor

Good instructors are diligent about helping students do well on the test—without giving away the questions or otherwise compromising the integrity of the exam process. However, students should never hesitate to ask instructors for guidance.

What do you need to know to succeed in class? Instructors should be able to identify the topics to concentrate on when studying for the exam. They should also quiz you with sample test questions similar to what you'll see on the final. My *Hazmat Chemistry Study Guide* contains almost 400 examples, but they're written by one author who hasn't reviewed every hazmat chemistry exam nationwide. So ask your instructor.

Instructors should be able to identify the topics to concentrate on when studying for the exam.

What do you need to know to function safely and effectively in the real world? This is not always the same as what you need to know to pass the test. A 100-question multiple choice test is a far cry from the field test of a real incident.

Are there any test questions known to be problematic? If questions are badly written or difficult to understand, contain outdated (or wrong) information, are frequently misinterpreted by students, or cover trivia students won't normally think to study, it's not compromising the integrity of the test for instructors to give students some additional guidance. The goal, after all, should be to make sure students learn these important concepts, not to frustrate students with bad questions.

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Focus on Concepts More than on Chemicals

While every test is different and there's no way for this author to know what questions you'll have on your final exam, it's not uncommon to get questions that focus more on *concepts* than on *chemicals*. Let's look at one example.

Among the things you'll learn in a hazmat chemistry class is that some gases exist as molecules of two identical atoms. We call those *diatomic gases*. You should be familiar with one of them already—oxygen (O_2). Oxygen as an element (O) cannot exist by itself. It must bond with something to be stable. Oxygen can, and does, bond with many elements, including other oxygen atoms. If you understand the definition of a diatomic gas and you've seen an example (O_2), you should be able to recognize other diatomic gases by looking at a chemical formula.

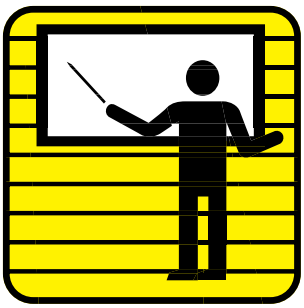
Which of the following is a diatomic gas?

a. CO
b. CO_2
c. Cl_2
d. CH_4

In the question above, there's only one answer (c) comprised of two identical atoms—chlorine (Cl_2). While the others are common gases you should be able to recognize—carbon monoxide (CO), carbon dioxide (CO_2), and methane (CH_4)—you can easily answer the question without knowing what the compounds are.

Many questions are like this. If you understand the concept, you can correctly answer the question without naming the compounds. This idea is important enough that we'll look at it in more depth shortly.

Many test questions focus more on *concepts* than on *chemicals*. Understanding this can help you answer questions even if you can't name a chemical compound.



Aim High When You Study

Expect some vocabulary questions, but plan for questions that require you to apply the information. Let's look at three sample questions with different degrees of difficulty.

A polymerization reaction is best described as one that:

a. Is highly toxic
b. Generates heat
c. Involves rapid expansion as a hazardous material reacts with itself
d. Results in fire when a hazardous material oxidizes on exposure to air

Which of the following materials are most prone to runaway polymerization?

a. Oxidizers
b. Organic peroxides
c. Cryogenic liquids
d. Dangerous when wet materials

Expect some vocabulary questions, but plan for questions that require you to apply the information.

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Which of the following measures is an example of how to prevent polymerization reactions?

a. Preventing water from coming in contact with salts
b. Avoiding filling a compressed gas cylinder too quickly
c. Avoiding applying a water stream to the hot surface of burning oil
d. Protecting organic peroxides from heat, friction, and contamination

The first question is a simple vocabulary question. It does little more than test that you can define the term *polymerization* (answer c). The second question also requires you to know what polymerization means, but it takes a step further in asking you to identify substances most prone to runaway polymerization (answer b). The third question is the best of the bunch, because it accomplishes everything the first two questions do plus reflects how you might use the information at a hazmat incident (answer d). It's the kind of question that I prefer when writing tests.

Test questions can be categorized based on their level of difficulty and what they require of students:

- Level 1 - Basic Knowledge — Requires students to recall, recognize, or identify.
- Level 2 - Competent — Requires students to apply information learned to prescribed problems.
- Level 3 - Highly Proficient — Requires students to apply information learned to a new set of circumstances. Students need to think beyond what was taught in class.

It's not uncommon for tests to have an abundance of Level 1 and Level 2 questions, because they're the easiest to write. However, real life is often more demanding. So you should aim for a higher level of proficiency when studying. Let's look at three more questions to illustrate this concept.

A normal atmosphere contains approximately _____ oxygen.

a. 19%
b. 20%
c. 21%
d. 22%

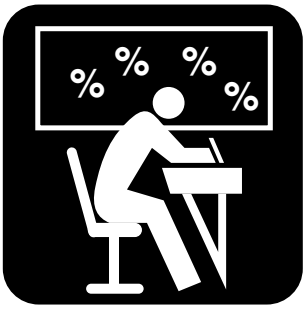
The normal atmosphere contains approximately 20.9% oxygen, so answer c is the closest match. This question requires nothing more than simple recall (Level 1). It's important information, but what will you do with it?

Your meter displays a reading of 19.9% oxygen (a 1% drop from normal). How much of a displacing gas (contaminant) is likely to be present?

a. 1%
b. 3%
c. 5%
d. 7%

The question above requires you to apply information taught in class to a simple job-related scenario (Level 2). Simple, but very important. And often a source of confusion for students.

It's not uncommon for tests to have an abundance of Level 1 (basic knowledge) and Level 2 (competent), questions because they're the easiest to write.



However, because real life is often more demanding, students should aim for a higher level of proficiency when studying.

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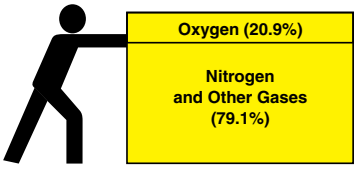
Oxygen comprises roughly one fifth (20.9%) the normal atmosphere. When your meter shows an oxygen level of 19.9%, you need to recognize that it reflects only oxygen displacement. When a contaminant gas or vapor displaces oxygen, it also proportionately displaces nitrogen and other gases that make up the total atmosphere (one part oxygen, four parts everything else). So the amount of contaminant likely to be present is close to 5%, not 1%. The illustration below helps clarify this concept.

Atmospheric Displacement
(1 Part Oxygen, 4 Parts Nitrogen and Other Gases)



Now let's look at a Level 3 example. It's more than may be expected of you in a hazmat chemistry class, but certainly something you should understand as you get further in your training.

> You get a reading of 20.5% oxygen in an atmosphere suspected to contain acetone vapors. Acetone has a lower explosive limit (LEL) of 2.5% and an upper explosive limit (UEL) of 12.8%. What do these initial oxygen readings suggest?
>
> a. The acetone concentration may be below the LEL
> b. The acetone concentration may be within the flammable range
> c. The acetone concentration may be above the UEL
> d. The initial readings do not provide any information that can be used to predict flammability

This scenario assumes you haven't yet monitored for acetone itself; you're merely looking at oxygen levels. So let's work through the math. A 0.4% drop in oxygen level (20.9% – 20.5% = 0.4%) represents a 2.0% displacement of the normal atmosphere (0.4% x 5 = 2.0%). Thus the acetone concentration is likely to be below the LEL of 2.5%. Further monitoring is obviously required, but initial readings do provide some useful information.

Most of us don't like to study this hard when preparing for a final exam. But once again, real life is far more demanding than any written test you'll ever take, so it's to your benefit to aim for a higher level of proficiency when studying in any class.

Recognizing the Concepts Behind the Questions

One recommendation made in the preceding pages was to focus on *concepts* more than on *chemicals*. If you understand the concepts, you can often correctly answer the test questions without putting names to the formulas or knowing more about the compounds.

Level 3 (highly proficient) questions require students to apply information learned to a new set of circumstances. Students need to think beyond what was taught in class.

If you understand the concepts, you can often correctly answer the test questions without putting names to the formulas or knowing more about the compounds.

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Does this mean you shouldn't diligently study the material? Certainly not. What it does mean, however, is that you can reduce your test anxiety a little. More importantly, it helps you in the real world, because it enables you to streamline your identification and hazard analysis process. So we'll look at some examples over the next few pages.

Concept: Molecular size affects the behavior of many materials. For instance, smaller hydrocarbon molecules are more active, produce more vapor, and have a higher vapor pressure than do larger hydrocarbon compounds similar in structure at the same temperature and pressure. (Other physical and chemical properties are affected too, but we'll focus just on vapor pressure here.)

The two questions below are identical, and the answers are the same in each, except that one contains formulas and the other contains names. Each question tests whether you recognize the relation between molecular size and vapor pressure. Again, the smaller the compound, the higher the vapor pressure.

Which of the following has the highest vapor pressure?

a. C_3H_8
b. C_4H_{10}
c. C_5H_{12}
d. C_6H_{14}

Which of the following has the highest vapor pressure?

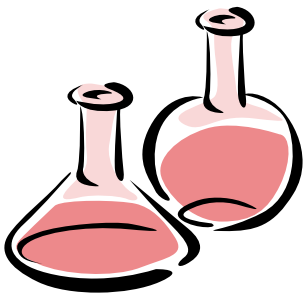
a. Propane
b. Butane
c. Pentane
d. Hexane

You don't have to name the compounds in the first question if you recognize that C_3H_8 (answer a) is the smallest compound listed. (Hint: It has the fewest atoms.) Likewise, you don't need to know the formulas to successfully answer the second question. Each compound ends in *-ane*, so they're all alkanes, meaning they all have similar structures. All you need to know at this point is the relation between the prefixes and the number of carbon atoms (*prop* means 3, *but* means 4, *pent* means 5, and *hex* means 6). Propane (answer a) has the fewest carbon atoms (and consequently the fewest total atoms), so it's the smallest compound.

Concept: Compounds are categorized as either salts or nonsalts. Most *salt* compounds are comprised of a metal element plus one or more nonmetal elements. (Metal and nonmetal elements can be distinguished by looking at the periodic table of elements. *Nonsalt* compounds are comprised of two or more nonmetal elements.

There are very few salts that don't contain metal elements. Examples include ammonium chloride (NH_4Cl) and ammonium nitrate (NH_4NO_3). But for now, we'll ignore those exceptions.

Understanding concepts can help you reduce test anxiety.



More importantly, it can help you in the real world, because it enables you to streamline your identification and hazard analysis process.

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Understanding the distinction between salts and nonsalts should make it very easy to answer the questions that follow. Does the name or formula contain a metal element? If so, the compound is a salt. If not, it's most likely a nonsalt. (You should be able to spot the metal elements used in the questions below on a periodic table.)

Which of the following compounds is a salt?

a. Methyl Chloride
b. Sodium Cyanide
c. Vinyl Acetate
d. Hydrogen Peroxide

Which of the following compounds is a nonsalt?

a. Sodium Hypochlorite
b. Potassium Permanganate
c. Lithium Bromate
d. Methyl Cyanide

These first two questions require you to recognize the names of metal elements (or be able to find them on a periodic table). Sodium is a metal element, so sodium cyanide (b) is the correct answer to the first question. The second question has only one name that doesn't contain a metal element (methyl cyanide), so the answer is d. Now see what you can do with symbols, also found on a periodic table.

Which of the following compounds is a salt?

a. H_2O_2
b. $CH_3OC_2H_5$
c. $CaSO_4$
d. CH_3CN

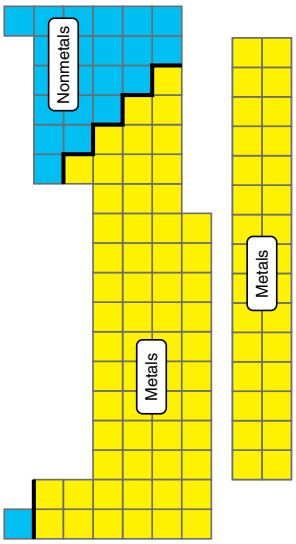
Which of the following compounds is a nonsalt?

a. CaC_2
b. KCN
c. C_2H_5OH
d. NaClO

The last two questions are very similar except that you're given formulas instead of names. Calcium (Ca) is a metal element, so $CaSO_4$ (answer c) is correct for the third question. And only C_2H_5OH (answer c) in the last question has no metal in the formula, making it the one nonsalt.

Notice that all four of the preceding questions can be answered without putting a formula to a name or vice versa. Should you be able to match names and formulas? Absolutely. It's likely that some questions on your final exam will even require you to do so. But understanding the concepts behind the chemistry can help you pick the correct answers with far less anxiety.

Understanding the distinction between salts and nonsalts should make it easy to recognize them by name or formula.



If the name or formula contains a metal element, the compound is a salt. If not, it's mostly likely a nonsalt.

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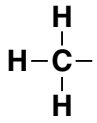
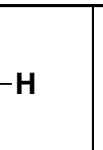
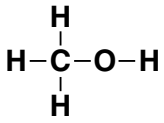
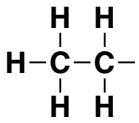
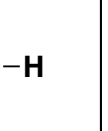
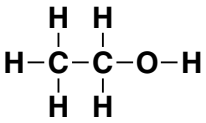
Concept: Hydrocarbon derivatives are comprised of one or more hydrocarbon radicals attached to a functional group. The graphic below illustrates two examples. In the first column are the hydrocarbon radicals methyl and ethyl. The second column shows the functional group, a hydroxyl (OH) group in both cases. Finally, when the radicals are added to the functional group, the result is methyl alcohol (top) and ethyl alcohol (bottom). Both are in the greater hydrocarbon derivative family known as alcohols and can be recognized by the hydroxyl (OH) group in the formula.

The Making of Hydrocarbon Derivatives

Hydrocarbon Radical +	Functional Group =	Hydrocarbon Derivative
		
Methyl (CH_3)	Hydroxyl (OH)	Methyl Alcohol (CH_3OH)
		
Ethyl (C_2H_5)	Hydroxyl (OH)	Ethyl Alcohol (C_2H_5OH)

The key to recognizing each type of hydrocarbon derivative is to isolate the functional group within the formula. Below are a few examples. The table lists five hydrocarbon derivative categories along with the functional groups that comprise them. Those functional groups are underlined to help you recognize them. This is significant because instead of recognizing entire formulas, you can concentrate on picking out the functional groups and identifying what type of hydrocarbon derivatives they're associated with.

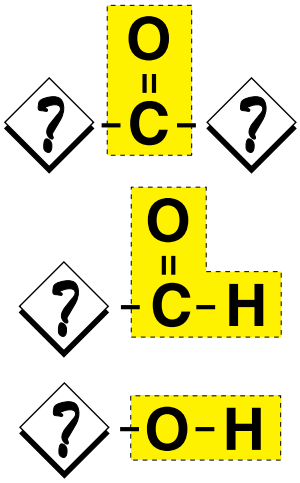
Hydrocarbon Derivative	Functional Group	Example	Name
Ketones	CO	$CH_3\underline{CO}CH_3$	Dimethyl Ketone (Acetone)
Aldehydes	CHO	$H\underline{CHO}$	Formaldehyde (Methanal)
Organic Acids	COOH	$CH_3\underline{COOH}$	Acetic Acid (Ethanoic Acid)
Esters	COO	$CH_3\underline{COO}C_2H_3$	Vinyl Acetate
Alcohols	OH	$C_2H_5\underline{OH}$	Ethyl Alcohol (Ethanol)

Before you look at the following questions, take a moment to study the table above and memorize the first two columns. When you've done so, try the first two questions.

CH_3COCH_3 is a/an:

a. Ketone
b. Aldehyde
c. Ester
d. Organic acid

Hydrocarbon derivatives are comprised of one or more hydrocarbon radicals attached to a functional group.



The key to recognizing each type of hydrocarbon derivative is to isolate the functional group within the formula.

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Which of the following is an aldehyde?

a. CH_3COCH_3
b. CH_3COOCH_3
c. CH_3COOH
d. CH_3CHO

Answering the two questions above should be easy if you understand the relation between functional group and type of hydrocarbon derivative. In the first question, CO is the functional group surrounded by two hydrocarbon radicals (CH_3). That signifies a ketone (answer a). Aldehydes contain the function group CHO, so CH_3CHO (answer d) is correct for the second question. Notice that you can answer both questions without putting names to the formulas.

Warning: Despite the repeated emphasis on *concepts* versus *chemicals*, don't be lulled into thinking that you won't have to put names to formulas (or vice versa) on your final exam. It's quite possible you may have several questions that require you do to just that. And you'll certainly need to do it in the real world. However, your knowledge of the basic concepts will help you immensely. Consider the following question.

Which of the following formulas represents methyl ethyl ketone (MEK)?

a. CH_3COCH_3
b. CH_3COOH
c. $CH_3COC_2H_5$
d. $CH_3O_2C_2H_5$

If you haven't memorized the formula for MEK, you'll need to look for two clues. Look for the functional group associated with ketones (CO). Answers a and c both contain that. Then look for the hydrocarbon radicals methyl (CH_3) and ethyl (C_2H_5), which are found in answers c and d. (Hydrocarbon radicals were mentioned briefly on the previous page.) The one formula that meets both requirements is $CH_3COC_2H_5$ (answer c).

Is it necessary to name all four compounds to correctly answer the question above? No. Should you be able to name them. Yes. Again, it may be vital in the real world. However, you can pass the test without doing so. Once you've recognized the value of focusing on *concepts* more than on *chemicals*, it makes studying for the final exam infinitely easier.

* * *

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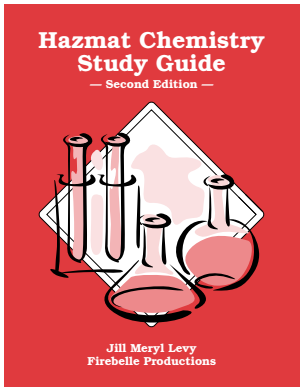
The *Hazmat Chemistry Study Guide* reviews information covered in many hazmat chemistry classes nationwide.



The book also contains almost 400 multiple choice test questions similar to those often found on final exams.

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