

# ACT SCIENCE QUICK GUIDE

Use this packet as a quick reference for the most important ACT Science tips and strategies.

**Key Strategy #1:** Use your first 20 seconds on each passage to do a few key things:

1. Distinguish graphs that look similar to one another, noting their figure numbers
2. Note whether graph axes run opposite the direction you're used to
3. Note whether any of the vertical axes refer to "percent"
4. Note whether there are keys and/or multiple curves on graphs
5. Identify how many experiments or studies there are

### Experiment 2

The conduction delay was determined for pure samples of PS1–PS4 at 100 °C. Each sample contained 1 of 4 antioxidants at a concentration of 300 mg/kg (see Figure 2). Antioxidants inhibit the decomposition of styrene exposed to air.

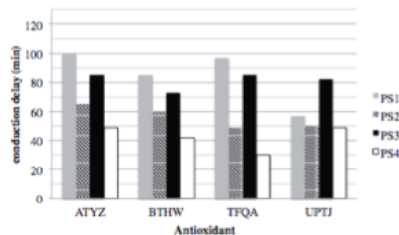


Figure 2

### Experiment 3

The conduction delay was determined for pure samples of PS1–PS4 at 100 °C. Each sample contained a different concentration of the antioxidant ATYZ (see Figure 3).

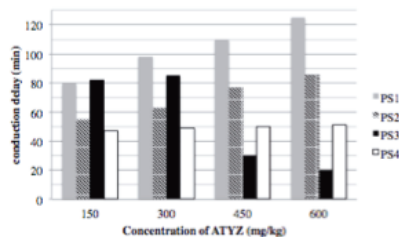


Figure 3

Be aware that there are multiple figures that look the same. Go to the right one!

Know that there are keys in play, and watch your axes!

**Key Strategy #2:** Use the text to your advantage!

1. Important terms, definitions, and explanations can often be found in the text in the passage's introduction or above/below figures and tables. If you need more information to make a decision, or if you're not sure how the information the data presents is related to the question, it's likely buried in the text.

*Example*

Date	Treatment	Mean <i>H/D</i> Ratio
October 2010	No Shelter	56
	120 cm Shelter	73
	150 cm Shelter	72
December 2010	No Shelter	48
	120 cm Shelter	66
	150 cm Shelter	67

According to the table, in which treatment and in which year did the scientists observe the highest degree of seedling stability?

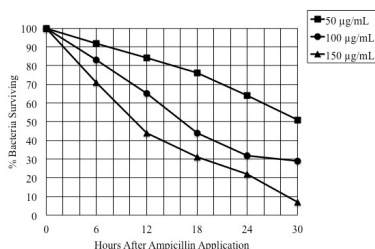
- A. No Shelter, October 2010
- B. 150 cm Shelter, October 2010
- C. No Shelter, December 2010
- D. 150 cm Shelter, December 2010

The only numbers you have are H/D ratios, but what does that mean, and what does it have to do with “stability”, which is what the question focuses on? NEVER assume “higher is better”. In fact, the text for the table above reads:

A lower H/D ratio indicates stable growth, whereas a high H/D ratio indicates a seedling struggling to grow. Table 1 shows the mean H/D ratio for seedlings in all three groups.

Thus, most stable = lowest number. Choice C is correct, since of the four choices offered, its H/D ratio is the lowest.

2. If a condition doesn't appear in the graph, the text likely states that this condition is held constant for all samples on that graph...so don't worry about it.

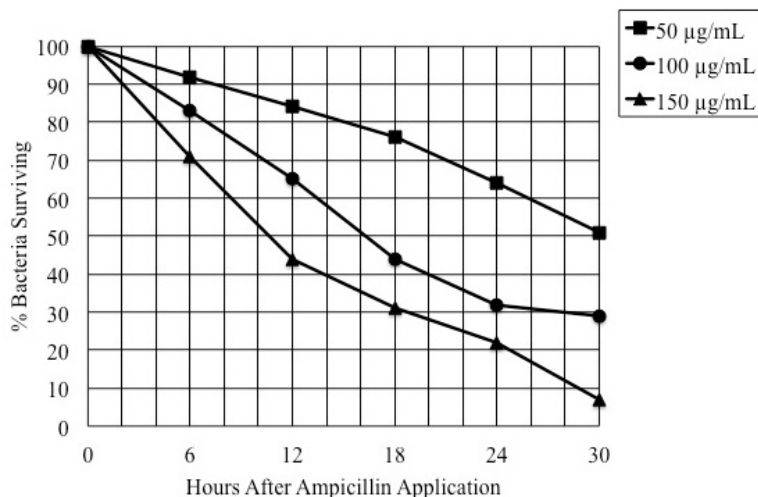


*Example*

What is the percent bacterial survival after incubating the plates at 40 °C for 12 hours with 100 µg/mL Ampicillin?

Temperature isn't indicated at all in the graph, so it's probably held constant for all curves that appear in this graph.

**Key Strategy #3:** ALWAYS make sure you're interpreting your axes correctly, and ALWAYS make sure you're using the proper curve.



*Example*

According to the figure, after approximately how many hours did the 150 µg/mL Ampicillin treatment eliminate 40% of the bacteria?

- A. 8 hours
- B. 10 hours
- C. 12 hours
- D. 20 hours

First, make sure you're using the curve with triangle markers, since the key makes it clear that this is the 150 µg/mL Ampicillin curve. Second, look at what the y-axis is showing: it says "% bacteria surviving", NOT "% bacteria eliminated", which is what the question wants. To find 40% elimination, you'd actually have to look for 60% survival ( $100 - 40 = 60$ ). The curve hits this point at approximately 8 hours, so Choice A is correct.

**Key Strategy #4:** NEVER assume tables provide values in order – read the full table!

*Example*

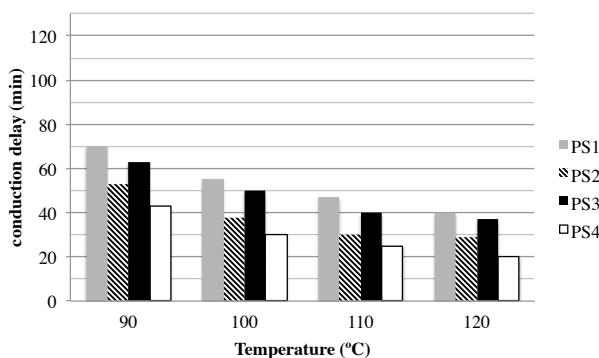
External Temperature (°F)	Emissions (ppm)
110	25
120	65
130	78
140	94
150	43
160	58

According to the table, as external temperature increased, emissions concentration:

- A. increased.
- B. decreased.
- C. increased, then decreased.
- D. did not vary predictably.

NEVER assume that the pattern in the first few entries of a table will continue, unless you're asked to extrapolate beyond the data given (more on that later). If you take a quick look at all of the paired values of temperature and emissions in the table, you'll see that while the initial relationship appears to be direct (temperature and emissions both seem to increase together), this relationship breaks down at 150 F, at which point the emissions drop, only to rise again at 160 F. Therefore, there is no relationship, so Choice D is correct.

**Key Strategy #5:** If you are asked about an unknown data point outside or within the range of given values, look to continue a consistent pattern to predict the value.



*Example*

According to the figure, if the experimenters had observed the samples at a temperature of 105 °C, the conduction delay of PS3 most likely would have been...

The trend in the graph shows the conduction delay of PS3 decreasing with increasing temperature; PS3's delay at 105 °C should thus be between its delays at 100 °C and 110 °C.

**Key Strategy #6:** Use the phrasing in the answer choices to direct yourself to the relevant information, especially if you don't know where to start. Try to eliminate answers based on plainly false assertions.

*Example*

In wastewater treatment procedures, *effluent* is defined as the outflow of treated sewage into a natural body of water, such as a stream. The amount of effluent per unit of natural flowing water is known as the *effluent of stream ratio*, or EOSR. Though the effluent is treated, a higher EOSR correlates with a higher concentration of bacteria in the stream. Scientists performed an experiment to measure the EOSR for each of four streams receiving treated discharge from sewage plants located in the geographical region.

Stream	EOSR
A	0.594
B	0.258
C	0.773
D	0.638

Table 1

Suppose the scientists had determined the EOSR for a fifth stream, designated as Stream E, to be 0.494. According to Table 1 and the information provided, compared to the concentration of bacteria in Stream B, the concentration of bacteria in Stream E is likely to be:

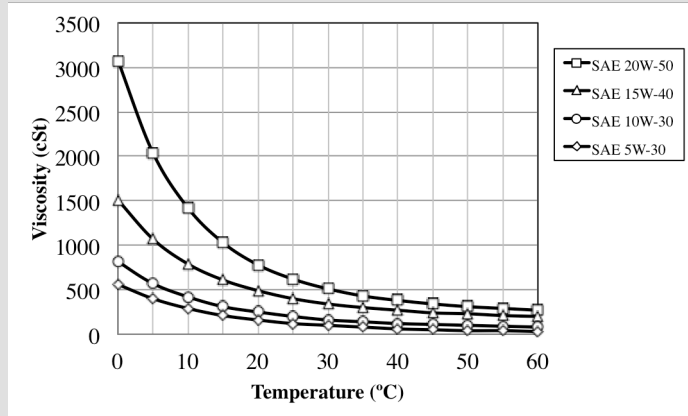
- A. higher, because the EOSR of Stream E is higher than the EOSR of Stream B.
- B. higher, because the EOSR of Stream E is lower than the EOSR of Stream B.
- C. lower, because the EOSR of Stream E is higher than the EOSR of Stream B.
- D. lower, because the EOSR of Stream E is lower than the EOSR of Stream B.

There's a lot of information here, but notice that the answer choices refer to the EOSR. We can actually eliminate choices B and D immediately, because they falsely state that the EOSR of Stream E is lower than that of Stream B (compare the value of Stream E's EOSR given in the question to Stream B's EOSR given in the table). Also, since the answers all focus on EOSR, this must mean that there is some relationship between EOSR and bacterial concentration. While this isn't revealed in the table, it is revealed in the text above the table, which states that "a higher EOSR correlates with a higher concentration of bacteria in the stream". This means that Stream E, which has the higher EOSR, will also have the higher concentration of bacteria. Thus Choice A is correct.

**Key Strategy #7:** When a question references two data sources, find the “bridge” between the two and use both!

*Example*

Oil Sample	$\Delta_{\eta}$
SAE 20W-50	0.00990
SAE 15W-40	0.02174
SAE 10W-30	0.03846
SAE 5W-30	0.05263



A new oil sample is tested and is found to have a  $\Delta_{\eta}$  of approximately 0.08. According to the table and the graph, as temperature increases, the new oil sample’s viscosity would be expected to decrease:

- A. more quickly than any of the other sample’s viscosities.
- B. more slowly than any of the other sample’s viscosities.
- C. more quickly than the viscosities of SAE 5W-30 and 10W-30, but more slowly than the viscosities of SAE 15W-40 and SAE 20W-50.
- D. there is not enough information to determine the rate of the new sample’s change in viscosity.

The question tells us to refer to the table and the graph for good reason: using the table, we must compare the  $\Delta$  of the new sample to that of the samples already tested, and then use the graph to determine the relationship between the  $\Delta$  of a sample and its viscosity’s rate of decrease with increasing temperature. We can see that the value of the  $\Delta$  for the new sample is higher than any of the others given. How does this relate to the graph? By using the key to pair each viscosity curve with its oil’s value of  $\Delta$ , we can see that the higher the value of  $\Delta$ , the more slowly the viscosity decreases with increasing temperature (you can tell as much by the decreasing steepness of each curve as the value of  $\Delta$  increases). This is the “bridge” between the table and the figure. Thus Choice B is correct.

**Key Strategy #8:** When asked about a “control”, look for a sample that hasn’t been “treated”. This could appear as a “zero” value in a table or be cited in the text as a sample or trial that does not receive a treatment.

*Example*

Bacterial colonies were plated in triplicate for each trial. The average number of bacteria in each triplicate plating was estimated by counting using a light microscope before each trial was begun. 2 mL of a particular concentration of the antibiotic amoxicillin were added in each of the first three trials; in the fourth trial, 2 mL of distilled, deionized water were added to the plates. After 2 hours of incubation at 37 °C, the bacteria on each plate were counted, and the average number of bacteria was again determined. The results are shown in Table 1.

Trial	Amoxicillin Concentration (μmoles)	Initial # of Bacteria ( $N_0$ )	Final # of Bacteria ( $N_t$ )	% Change
1	20	1500	575	-62
2	30	1875	550	-71
3	40	1450	500	-66
4	0	1300	2000	+54

Table 1

Which of the trials served as a control for the experiment?

- A. Trial 1
- B. Trial 2
- C. Trial 3
- D. Trial 4

An experimental control is a baseline or “standard” to which all other samples are compared. The control sample never receives the treatment, which is the thing being tested (in this case, concentration of the antibiotic amoxicillin), but is otherwise handled in the same way as the other samples. This is to ensure that the results of the other trials are due to the treatment being tested rather than some other external variable. Here, both the table and text make clear that the Trial in which no antibiotic was applied to the plates was Trial 4. Thus Choice D is correct. Note that instead of antibiotic, water was applied in this trial. This is to ensure the simple process of adding something to the plates was not the cause of any population changes.

**Key Strategy #9:** When asked which variables the experimenters “controlled”, this is not the same as a “control” (discussed in Key Strategy #8): this concerns which variables the experimenters “had control over”, or were able to manipulate/determine themselves. Look to the text!

*Example*

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4	0	1300	2000	+54

Table 1

In conducting the experiment, which of the following lists all conditions controlled by the experimenters?

- A. Amoxicillin concentration only.
- B. Amoxicillin concentration, temperature, incubation time, and final number of bacteria.
- C. Amoxicillin concentration, temperature, and incubation time.
- D. Amoxicillin concentration, incubation time, and final number of bacteria.

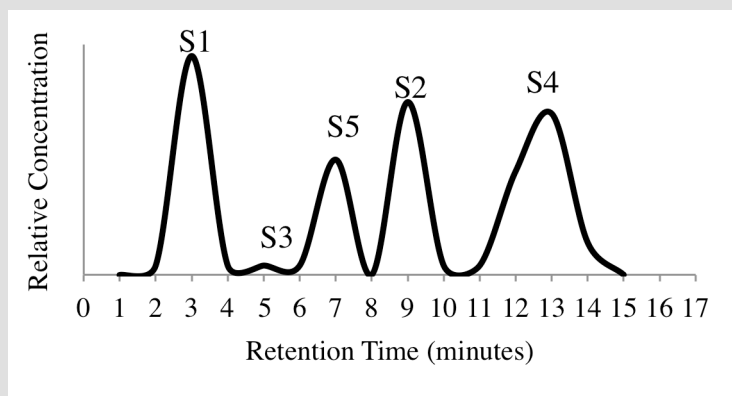
This question requires that you have a basic understanding of how this experiment was set up, which can come only from the text. Give that a brief read, and you'll realize the scientists are able to manipulate the concentration of amoxicillin, and the time and temperature of incubation. However, the final number of bacteria is not determined by the scientists: that's what's being observed, or measured, in response to the changing concentration of amoxicillin. The “result” is thus often called the “response” (dependent) variable. Thus, Choice C is correct.



**Key Strategy #10:** When asked to order values, look for extremes and eliminate quickly. Pay attention to the relationship you're supposed to order!

*Example*

A technique known as *column separation* can be used to separate compounds based on their molecular masses. A mixture of compounds is dissolved in the liquid phase, and the liquid is injected into a column, known as a *matrix*, through which the molecules in the liquid migrate over time. The time a given compound spends moving through the column is known as *retention time*, and is inversely related to a compound's molecular mass. The *elution*, or complete movement of the compound through the column, is made obvious when a peak is observed on a graph of relative concentration in the sample eluted over time. A group of students used column separation to distinguish the molecular weights of five compounds (S1 through S5). The results are shown below in Figure 1.



Which of the following correctly orders the molecular masses of the samples from least to greatest?

- A. S1, S2, S4, S5, S3
- B. S3, S5, S4, S2, S1
- C. S4, S2, S5, S3, S1
- D. S1, S3, S5, S2, S4

The question is asking you to order samples in order of their molecular mass, not their retention time! The graph doesn't directly indicate the mass of each compound, so we must turn to the text, where it is revealed that the two are inversely related. This means that as retention time goes up, mass will go down. This means you'll have to look for the first compound in the list to be S4. This is our "extreme" because it has the highest retention time, or lowest mass. The highest-mass compound should be S1, because it has the lowest retention time. Choice C is therefore correct.

**Key Strategy #1.1:** When you encounter the “Conflicting Viewpoints” passage, read the introductory material, but not the different viewpoints, before going to the questions. Save this passage for last if you tend to run short on time.

4 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ 4

**Passage V**

*Introduction*

A *cell-surface receptor* is a protein molecule embedded in the cell membrane of animal cells. Receptors are used to allow the entry of specific essential biomolecules (such as proteins and nutrients) into cells whose membranes would otherwise block these molecules from entry. When a specific biomolecule (the *substrate*) binds to a cell-surface receptor specific to that molecule, the receptor undergoes a change in *conformation* (shape), which in turn initiates a change in the shape of the cell membrane that allows entry of the biomolecule into the cell.

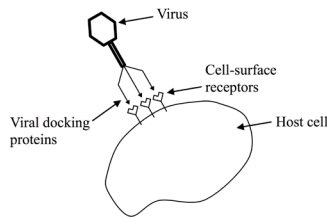


Figure 1

Certain viruses can enter an animal (host) cell by producing *docking proteins* that mimic the shape of a normal biomolecule. These proteins dock on (bind to) the cell-surface receptors specific to the molecules the viral proteins mimic, initiating the change in the shape of the cell membrane that allows viral particles to enter the host cells and replicate, leading to infection. New *anti-viral drug treatments* seek to disrupt viral entry by interrupting this process. Three hypotheses propose mechanisms for the action of the anti-viral drugs.

*Hypothesis 1*

Anti-viral drugs deliver engineered molecules to a host’s blood system. These molecules then bind to and destroy the specific viral docking proteins used to mimic the normal substrate molecules. Because these docking proteins are physically damaged, the virus can no longer bind to the cell-surface receptors, and the viral particles can no longer enter the cell.

*Hypothesis 2*

Anti-viral drug molecules enter a host’s bloodstream and bind specifically to the virus’s docking proteins. Upon binding, these molecules initiate a change in the conformation of the viral docking proteins. This shape alteration changes the specificity of the viral docking protein such that it will no longer bind to the cell-surface receptor. Because the viral protein cannot bind to the cell-surface receptor, viral particles can no longer enter the cell.

*Hypothesis 3*

To block the entry of viral particles into the host cell, anti-viral drug molecules mimic the shape of a substrate that normally binds to cell-surface receptors. This enables the anti-viral drug particles to bind to the cell-surface receptors. Once the particles and cell-surface receptors are bound, the viral docking proteins can no longer bind the cell-surface receptors, and thus cannot enter the cell.

Skim the introductory material first to get the main idea. This contains details that are held as “true” for all hypotheses and viewpoints in the rest of the passage. The hypotheses or viewpoints may refer to concepts or terms that are described here.

Make sure you know which hypothesis or viewpoint each question references; read carefully to distinguish the viewpoints. Underline differences to keep the details straight.

**Key Strategy #12:** Draw simple arrow diagrams to visually summarize the relationships between variables, especially when presented with more than two that vary with one another.

*Example*

Color	Mean Frequency (THz)
Red	455
Orange	495
Yellow	525
Green	560
Blue	640
Violet	710

Table 1

*Wavelength* and *energy* are two properties of light waves. As the frequency of a light wave increases, its energy increases and its wavelength decreases. Suppose students conducting an experiment are working with *infrared* wavelengths, which have a lower energy than red light. Based on Table 1, compared to red light, one would expect infrared light to have:

- A. lower frequency and higher wavelength
- B. lower frequency and lower wavelength
- C. higher frequency and lower wavelength
- D. higher frequency and higher wavelength

The problem defines variables—wavelength and energy—that are not described in the data. However, the text does describe the relationship between each of these two variables and frequency, which is shown in the table. Drawing a simple arrow diagram can help you translate the words to something visual.

$$F \uparrow = E \uparrow$$

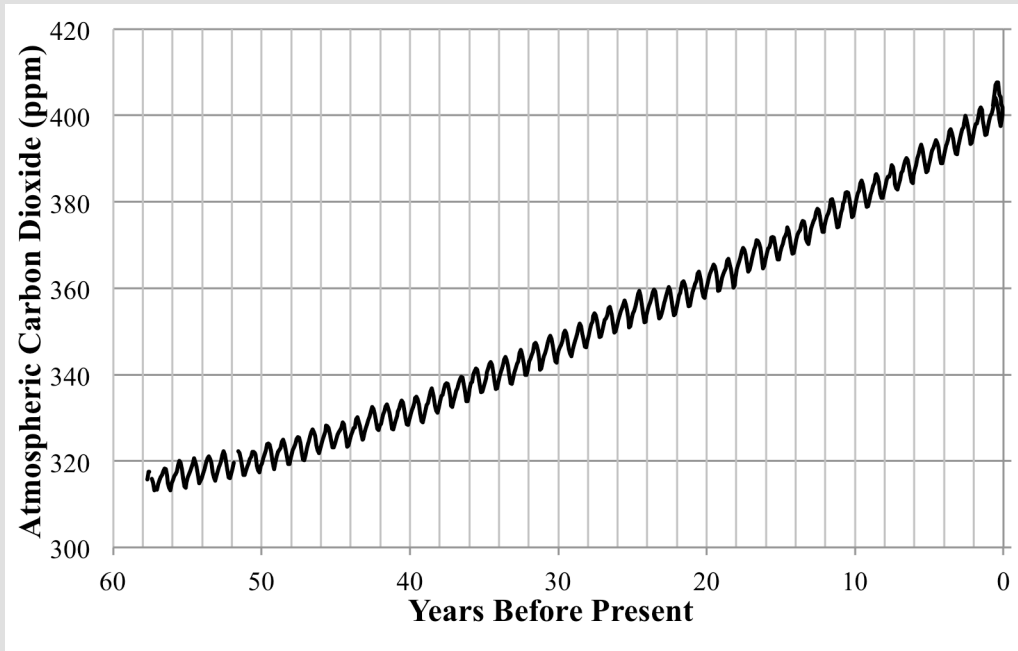
$$F \uparrow = W \downarrow$$

The diagrams can help us here, because the relationships must be preserved. Since infrared light has lower energy, our diagram tells us its frequency would be lower than red light's frequency; since its frequency is lower, its wavelength must be higher than red light's frequency. Thus, Choice A is correct.

**Key Strategy #13:** Questions specific to data collection have answers buried in the way the graphs are structured. Look for “zero” points.

*Example*

Figure 1 shows monthly atmospheric CO<sub>2</sub> measurements collected at a Mauna Loa monitoring station over approximately 60 years prior to 2016.



Based on Figure 1, compared to the current atmospheric CO<sub>2</sub> concentration, atmospheric CO<sub>2</sub> concentration in 1970 was approximately:

- A. 120 ppm lower.
- B. 80 ppm lower.
- C. 60 ppm lower.
- D. The information provided is insufficient to answer the question.

The big question is how we know where “current” (today’s) atmospheric CO<sub>2</sub> is on the graph, since there’s nothing that explicitly states the number. This is why it’s important to skim the text above the figure and look at your axes: notice the x-axis gives “years before present”...that means 0 represents today, because 0 years before present is now. It looks like the graph is at around 400 ppm here. Since the text tells us that “today” is 2016 (never assume that the graph is current!) 1970, which was 46 years ago must be represented by 46 on the x-axis, where the graph shows about 320 ppm. The difference is thus 80 ppm, so Choice B is correct.

**Key Strategy #13 continued:** When asked about how the data were collected, the answer can lie in the text accompanying a figure or table.

*Example*

According to Figure 1 and the information provided, how many times per year was atmospheric CO<sub>2</sub> measured?

- A. 1
- B. 10
- C. 12
- D. 15

Sometimes, the question concerns a purely procedural element of the experiment. Answers to these questions are most likely in the text that goes along with an experiment or figure. Here, the text indicates that CO<sub>2</sub> measurements were taken “monthly”. Since there are 12 months in a year, Choice C is correct.

**Key Strategy #14:** When a question gets overwhelming, split it up into chunks and go after one chunk at a time.

*Example*

Consider the volume of NH<sub>3</sub> produced by Day 3 from the AGF4 sample that contained no catalyst. Based on Figure 2 and Table 1, the AGF3 sample containing a catalyst produced the same volume of NH<sub>3</sub> by which of the following days?

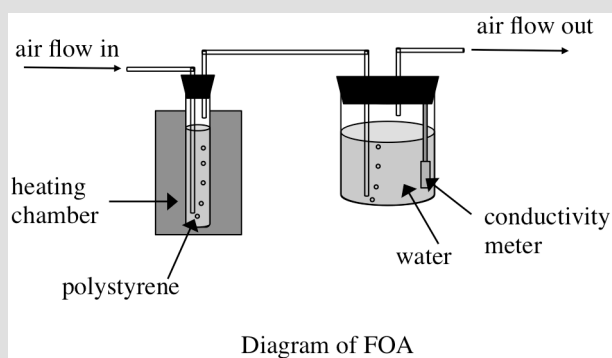
- A. Day 2
- B. Day 4
- C. Day 6
- D. Day 8

This question reads like a nightmare, but you simply can't let yourself get overwhelmed by abbreviations and references to experimental data. Instead of trying to digest the question all at once, break it into pieces. Focus first on the AGF4 sample without a catalyst on Day 3, and circle it wherever it's located (probably in Figure 2 or Table 1). Then, move to the AGF3 sample, find when it produces the same volume of NH<sub>3</sub>, and circle it. Then compare.

**Key Strategy # 15:** When asked an experimental procedure question, the text can be useful (see Key Strategy #13), but diagrams and a little outside knowledge can be helpful too.

*Example*

A 4 g styrene sample is heated to a particular temperature. Starting at time = 0 min, dry air from the external environment is bubbled through the sample at a constant rate. The airflow carries the resulting organic acids produced in the styrene into a flask holding deionized water.



In the FOA, the “air flow out” tube in the water chamber of the apparatus is most likely provided to ensure that:

- A. a vacuum is established inside the water chamber.
- B. the heated air that reaches the water chamber is cooled.
- C. the polystyrene sample can exit the apparatus.
- D. excessive pressure does not build inside the water chamber.

This is a typical “experimental procedure” question, in that it asks how or why something was done. You should look at a diagram whenever the question asks anything about something that appears within the setup diagrammed in the passage. Note that in the diagram of the FOA, the “air flow out” tube is not coming into contact with any liquid. This suggests that choice C is out. Because air is going out through this tube and not in, choice B, which suggests the air in the water chamber is cooled via this tube, is out. Choice A is incorrect, because if there were a vacuum, no air should be in the water chamber at all. This leaves Choice D, which makes sense: by allowing the air that passes from the test tube into the water chamber to exit the apparatus, dangerous pressure cannot build in the water chamber. This is a principle you would have touched upon in chemistry, but didn’t necessarily need to “learn” in order to figure out.