United States
Environmental Protection
Agency

Air Pollution Training Institute
MD 20
Environmental Research Center
Research Triangle Park, NC 27711

EPA 450/2-82-004
July 1983

EPA

APTI Correspondence Course 434 Introduction to Ambient Air Monitoring

Guidebook Second Edition

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Air

APTI Correspondence Course 434 Introduction to Ambient Air Monitoring

Guidebook Second Edition

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Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Notice

This is not an official policy and standards document. The opinions and selections are those of the authors and not necessarily those of the Environmental Protection Agency. Every attempt has been made to represent the present state of the art as well as subject areas still under evaluation. Any mention of products or organizations does not constitute endorsement by the United States Environmental Protection Agency.

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Course Introduction

Overview of Course

Course Description

This training course is a 50-hour correspondence course about ambient air quality monitoring. This course introduces terms used in air monitoring and presents practical information about the monitoring process. Theoretical monitoring concepts are also described. Course topics include the following:

- ambient air monitoring objectives
- ambient air sampling train design
- basic gas properties
- air movers and air measuring devices
- statistical techniques pertaining to air monitoring
- ambient sampling of particulate matter
- manual sampling of ambient gaseous pollutants
- calibration gas preparation
- reference methods and reference measurement principles for the criteria pollutants
- continuous air quality monitors
- air quality monitoring network design.

This course is divided into two parts, each with four sections. Part A includes background information pertinent to air quality monitoring. Part B includes sampling and monitoring techniques. If you are familiar with the topics presented in Part A, Lessons A1-A4 (listed on page 0-3), you can skip this part of the course by passing a proficiency test. This is discussed in more detail on page 0-4.

Course Goal

To familiarize you with general information about the reference methods and reference method principles for the criteria pollutants, continuous air quality monitors, air quality monitoring network design, and statistical techniques pertaining to ambient air monitoring. This course will also familiarize you with detailed information concerning basic gas properties, particulate matter sampling, manual sampling of ambient gaseous pollutants, and calibration of air quality monitors.

Course Objectives

Upon completion of this course, you should be able to:

1. identify at least six objectives of ambient air quality monitoring.
2. describe and correct for the effects of temperature and pressure on measured air volumes.

3. recognize at least seven air movers and at least 13 air measuring devices used in atmospheric sampling.
4. identify at least six inertial collection devices, optimum inertial sampling conditions, at least five inertial sampling sources of error, and two applications of the inertial sampling of particulate matter.
5. recognize considerations for the operation, maintenance, calibration of high volume samplers and identify and describe how to minimize potential sources of error in high volume sampling.
6. describe how at least four filtration mechanisms are affected by filter and sampling conditions and recognize the advantages and disadvantages of cellulose, glass fiber, and membrane filters.
7. recognize and describe the effects of at least five sampling conditions on the collection efficiencies of liquid absorbers.
8. identify and describe the effects of at least four sampling conditions on the adsorption of gaseous pollutants.
9. identify optimum conditions for preparing calibration gases using bags, permeation tubes, single dilution systems, and double dilution systems and calculate the concentrations of these gases.
10. recognize advantages and disadvantages of at least six adsorbents used in the preparation of zero air or the removal of water vapor from a gas stream.
11. identify the reference methods and reference measurement principles for the criteria pollutants.
12. recognize advantages and disadvantages of coulometric, amperometric, second derivative spectroscopic, flame photometric, fluorescence, chemiluminescence, ultraviolet photometric, and nondispersive infrared air quality monitors.
13. recognize major considerations in designing the sensor and data systems of an ambient air quality monitoring network.
14. interpret and construct statistical graphs for analyzing ambient air monitoring data.

Sequence, Lesson Titles, and Trainee Involvement Time

Lesson number	Lesson title	Trainee involvement time (hours)
Part A		
A-1	Introduction to Atmospheric Sampling and Basic Properties of Gases	6
A-2	Air Movers and Air Measuring Instruments	6
A-3	Inertial Sampling for Particulate Matter	6
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Part B		
B-1	High Volume Sampling of Particulate Matter and Evaluation of Filter Media	6
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Requirements for Successful Completion of this Course

In order to receive 5.0 Continuing Education Units (CEUs) and a certificate of course completion, you must achieve a final course grade of 70 (out of 100). You have two options for completing the course:

Option #1

- Complete Part A (Sections A1-A4) of this course.
- Take Quiz 1 under supervision.
- Complete Part B (Sections B1-B4) of this course.
- Take Quiz 2 under supervision.
- Take a supervised final examination.

If you choose Option #1, your grade will be determined as follows:

20% from Quiz 1
20% from Quiz 2
60% from the final examination

Option #2

- Ask your test supervisor for ***one*** of the examinations included in the test envelope. Take the exam under supervision, have it mailed in, and wait for the exam results. If you correctly answered 80% of the questions pertaining to part A, then you will ***not*** have to complete Part A of this course, nor will you have to take Quiz #1.
- Complete Part B (Sections B1-B4) of this course.
- Take Quiz 2 under supervision.
- Take a supervised final examination.

If you choose Option #2, your grade will be determined as follows:

40% from Quiz 2
60% from the final examination

Use of Course Materials

Necessary Materials

- *APTI Correspondence Course 434 Introduction to Ambient Air Monitoring: Guidebook, Second Edition*
- EPA 450/2-80-004, *APTI Course 435 Atmospheric Sampling: Student Manual, Second Edition*
- pencil or pen
- calculator would be very helpful

Use of this Guidebook

Relationship Between Guidebook and Assigned Reading Materials

This guidebook directs your progress through the reference text *APTI Course 435 Atmospheric Sampling: Student Manual, Second Edition.*

Description of Guidebook Sections

This guidebook contains reading assignment sections which correspond to lessons of the course.

Each section contains the following:

- reading assignment
- reading assignment topics
- section's learning goal and objectives
- reading guidance
- review exercise

Please ***do not*** write in this guidebook.

Instructions for Completing the Quizzes and Examinations

- You should have received, along with this guidebook, a separate ***sealed*** envelope containing two quizzes and two examinations.
- You must arrange to have someone serve as your test supervisor.
- You must give the ***sealed*** envelope containing the quizzes and examinations to your test supervisor.

[**Note:** If you would like to meet the proficiency qualification of Part A of the course, complete one of the examinations under the supervision of your test supervisor, have it mailed in, and wait for the exam results.]

- At designated times during the course, under the supervision of your test supervisor, complete the quiz(zes) and the final exam.
- After you have completed each quiz or exam, your test supervisor must sign a statement on the quiz/exam answer sheet certifying that the quiz/exam was administered in accordance with the specified test instructions.

- After signing the quiz/exam answer sheet, your test supervisor must mail the quiz/exam and its answer sheet to the following address:

  Air Pollution Training Institute
  Environmental Research Center
  MD 20
  Research Triangle Park, NC 27711

- After completing a quiz, continue with the course. Do ***not*** wait for quiz results.
- Quiz/exam and course grade results will be mailed to you.

If you have questions, contact:

Air Pollution Training Institute
Environmental Research Center
MD 20
Research Triangle Park, NC 27711

Telephone numbers:
Commercial: (919) 541-2401
FTS: 629-2401

Part A

You may skip Part A if you are familiar with the material presented here. Refer to page 0-4 of the Course Introduction for information about exempting this part of the course.

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ATTENTION

PLEASE READ CAREFULLY

You are now enrolled with the Air Pollution Training Institute. The enclosed materials are for your usage. You may keep the **printed** materials, however, any **slides or video/audio tapes are loaned materials and MUST be returned to the Institute.**

To receive Continuing Education Units (CEUs), and a certificate of completion, please submit the final examination to the APTI. We encourage you to complete the course within 30 days.

Students choosing **not** to take the final, should fill out this form, and return it **along with any slides or tapes**. This will ensure your cancellation from the course. Otherwise you will remain enrolled and **responsible for the loaned slides/tapes.**

IT IS VERY IMPORTANT THAT STUDENTS BE CONSCIENTIOUS BY PROMPTLY RETURNING THE LOANED MATERIALS, IN ORDER NOT TO DEPRIVE OTHERS OF THE CHANCE TO BENEFIT FROM THOSE MATERIALS.

Please direct all correspondence to:

Registrar
APTI MD-17
US EPA
RESEARCH TRIANGLE PARK, NC 27711

We are happy to provide you with this training.

Name: _____

Address: _____

_____

_____

Date: _____

I choose **not** to take the exam for course (SI/CC) #_____
Please cancel me from the course.

*** ERRATA ***

Requirements for Successful Completion of Course CC:434

In order to receive 5.0 Continuing Education Units (CEU's) and a certificate of course completion you must:

* complete and submit a final exam to the APTI

* achieve a final course grade of at least 70%.

The quizzes associated with the course are for review purposes. The answers are enclosed for the student to use to correct his or her own quizzes. This way the student can assses his/her understanding of the material before taking the final exam. Do not send in the answer sheets to the quizzes to be graded. **The final exam counts for 100% of the course grade.**

If you have questions please contact:

Registrar
Air Pollution Training Institute
US EPA MD-17
Research Triangle Park, NC 27711

(Please Print)

Address:

Name _____

Date _____

CC:434

Quiz 1

Answer Sheet

1.	a	b	c	●	
2.	●	F			
3.	a	b	c	●	
4.	T	●			
5.	●	b	c	d	
6.	a	●	c	d	e
7.	●	b	c	d	e
8.	a	b	c	●	e
9.	a	b	●	d	e
10.	a	b	c	d	●
11.	a	●	c	d	
12.	●	F			
13.	●	b	c	d	
14.	a	b	c	●	
15.	●	b	c	d	
16.	a	b	●	d	
17.	a	b	c	●	
18.	●	F			
19.	T	●			
20.	●	F			

I certify that this test was administered in accordance with the specified test instructions.

_____

Quiz Supervisor

7-83

(Please Print)
Address:

Name _____
Date _____

CC:434

Quiz 2

Answer Sheet

1.	a	b	●	d
2.	●	F		
3.	T	●		
4.	T	●		
5.	a	b	●	d
6.	●	F		
7.	T	●		
8.	●	F		
9.	a	b	c	●
10.	●	F		
11.	●	b	c	d
12.	●	F		
13.	●	F		
14.	●	F		
15.	●	F		
16.	●	F		
17.	●	F		
18.	●	F		
19.	●	F		
20.	●	b	c	d

I certify that this test was administered in accordance with the specified test instructions.

_____
Quiz Supervisor

7-83

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Quiz 1

- This quiz is intended to be a ***closed-book*** exam. Do ***not*** use your notes or books. You ***may*** use a calculator.
- You will have 30 minutes to complete the quiz.
- On the answer sheet, circle the letter that corresponds to the best answer to each question. Each correct answer is worth five points.

1. Which of the following is a(are) possible consideration(s) in selecting an air mover for atmospheric sampling?
   a. sampling flow rate
   b. physical/chemical nature of the air to be sampled
   c. portability of the air mover
   d. all of the above

2. True or False? Inertial sampling is based on the principle that the momentum of a particle in a moving air stream will cause the particle to be deflected less than the air in the vicinity of the particle when the air stream undergoes a sudden change in direction.

3. 77 degrees Fahrenheit equals ____(?)____ degrees Celsius.
   a. 38
   b. 6
   c. 20
   d. 25

4. True or False? Orifice meters are primary standard variable pressure rate meters.

5. If the available sampling time is 20 hours, and if the analytical method is accurate only for samples containing at least 10 μg of the pollutant, and if the air sample is expected to contain at least 1 $\mu g/m^3$ of the pollutant, then a sampling flow rate of at least ____(?)____ m^3/h is required.
   a. 0.5
   b. 1
   c. 2
   d. 10

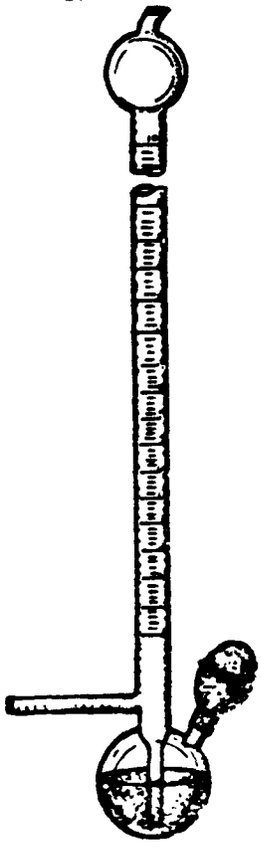
For each of questions 6 through 10, match the air measuring device with its appropriate diagram or description.

6. mass flow meter
7. wet test meter
8. rotameter
9. soap bubble meter
10. critical orifice

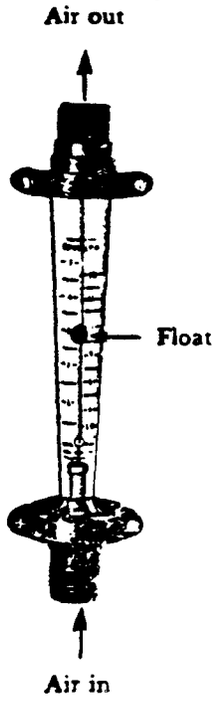
a. This device consists of a series of inverted buckets or traps mounted radially around a shaft and partially immersed in water. The locations of the entry and exit gas ports are such that the entering gas fills a bucket, displacing the water and causing the shaft to rotate due to the lifting action of the bucket full of air. The entrapped air is released at the upper portion of the rotation and the bucket again fills with water. In turning, the drum rotates index pointers that register the volume of gas passed through the meter.

b. This device works on the principle that as a gas passes over a heated surface, heat is transferred from the surface to the gas. The amount of current required to keep the surface at a constant temperature is a measure of the velocity of the gas.

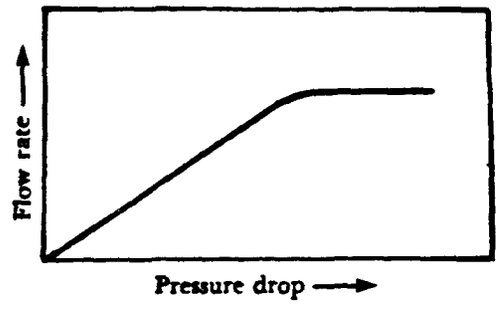
c.



d.



e.



11. Which of the following has no National Ambient Air Quality Standard (NAAQS)?
    a. sulfur dioxide
    b. hydrogen sulfide
    c. both a and b, above
    d. carbon monoxide

12. True or False? Particle size and density affect the collection efficiency of an inertial sampling device.

13. 0.140 ppm of SO_2 (molecular weight: 64 g/g•mol) at EPA's standard temperature and pressure (STP) conditions is equal to ____(?)____ $\mu g/m^3$ of SO_2.
    a. 366
    b. 400
    c. 53.5
    d. 0.366

14. Which of the following is a(are) potential source(s) of error in inertial sampling?
    a. particle shattering
    b. particle re-entrainment
    c. collection device calibration
    d. all of the above

For questions 15 and 16, select the appropriate equations used to correct air volumes or flow rates to EPA's STP conditions when measurements are made with the following types of meters.

15. volume meters
16. rate meters

a. $V_2 \text{ or } Q_2 = (V_1 \text{ or } Q_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$

b. $V_2 \text{ or } Q_2 = (V_1 \text{ or } Q_1)\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$

c. $V_2 \text{ or } Q_2 = (V_1 \text{ or } Q_1)\left[\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

d. $V_2 \text{ or } Q_2 = (V_1 \text{ or } Q_1)\left[\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

Where:
V_2 = corrected volume of air at EPA's STP
V_1 = measured volume of air at P_1 and T_1
Q_2 = corrected flow rate at EPA's STP conditions
Q_1 = measured flow rate at P_1 and T_1
T_1 = measured temperature of air, K
T_2 = 298 K
P_1 = measured pressure of air, mm Hg
P_2 = 760 mm Hg

17. Which of the following is a(are) possible objective(s) of ambient air quality monitoring?
    a. determine attainment of the National Ambient Air Quality Standards (NAAQS)
    b. evaluate progress in achieving/maintaining NAAQS
    c. provide data for initiating reductions of emissions during air pollution emergency episodes
    d. all of the above

18. True or False? The size of the jet and the jet's distance from the collection surface affect the collection efficiency of an inertial sampling device.

19. True or False? At constant temperature, the volume of a gas increases as the pressure exerted on it increases.

20. True or False? In air sampling trains, air movers and flow measuring devices are usually placed downstream of sample collection devices to avoid contamination of the sample air stream.

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Date _____

CC:434

Quiz 1

Answer Sheet

1.	a	b	c	d	
2.	T	F			
3.	a	b	c	d	
4.	T	F			
5.	a	b	c	d	
6.	a	b	c	d	e
7.	a	b	c	d	e
8.	a	b	c	d	e
9.	a	b	c	d	e
10.	a	b	c	d	e
11.	a	b	c	d	
12.	T	F			
13.	a	b	c	d	
14.	a	b	c	d	
15.	a	b	c	d	
16.	a	b	c	d	
17.	a	b	c	d	
18.	T	F			
19.	T	F			
20.	T	F			

I certify that this test was administered in accordance with the specified test instructions.

_____

Quiz Supervisor

7-83

CC:434

Quiz 2

- This quiz is intended to be a ***closed-book*** exam. Do ***not*** use your notes or books. You ***may*** use a calculator.
- You will have 30 minutes to complete the quiz.
- On the answer sheet, circle the letter that corresponds to the best answer to each question. Each correct answer is worth five points.

1. In calibrating a high volume sampler flow rate transfer standard, a ____(?)____ is connected to the inlet of a Roots meter and a ____(?)____ is connected to the Roots meter's outlet.
   a. mercury manometer, flow rate transfer standard/filter adapter assembly
   b. flow rate transfer standard/filter adapter assembly, water manometer
   c. flow rate transfer standard/filter adapter assembly, high volume sampler motor
   d. high volume sampler motor, flow rate transfer standard/filter adapter assembly

2. True or False? Sample air flow rate, bubble size, and the height of the absorbent column affect the collection efficiency of a liquid absorber.

3. True or False? The permeation rate of a permeation tube decreases as the temperature of the permeation tube increases.

4. True or False? Particle re-entrainment decreases as filter face velocity increases.

5. Under the conditions described below, the suspended particulate concentration obtained using a high volume sampler is ____(?)____ $\mu g/std\ m^3$.
   a. 222
   b. 182
   c. 200
   d. 12

   Given: Weight of filter after sampling: 3.432 g
   Weight of filter before sampling: 3.000 g
   Initial sampling flow rate: 1.65 std m^3/min
   Final sampling flow rate: 1.35 std m^3/min
   Sampling period: midnight 9-22-81 to midnight 9-23-81

6. True or False? An adsorbent's collection efficiency increases as its surface area increases.

7. True or False? The absorption of acid gases by glass fiber filters can be minimized by using glass fiber filters which have a basic pH.

8. True or False? In order to maintain a constant permeation rate, diluent gas passing over a permeation tube must be kept at a constant temperature and zero humidity.

9. Which of the following is a(are) desirable quality(ies) for an adsorbent?
   a. granular
   b. little or no resistance to air flow
   c. inert except for a specific adsorbate
   d. all of the above

10. True or False? Glass fiber filters can withstand high temperatures and corrosive atmospheres, and have high collection efficiencies.

11. If an SO_2 (molecular weight: 64 g/g•mol) permeation tube has a permeation rate of 2.000 μg/min at a temperature of 25 °C and a pressure of 760 mm of mercury, what is the SO_2 concentration (ppm) at EPA's STP conditions generated by a permeation system using the permeation tube and having a total dilution flow rate of 2.000 ℓ/min?
   a. 0.382
   b. 2.62
   c. 0.350
   d. 2.86

12. True or False? A modified vacuum cleaner motor, a stainless steel filter holder, and an 8" × 10" filter are components of a high volume sampler.

13. True or False? A calibration curve for a high volume sampler flow rate measuring device is constructed by plotting standard flow rates versus appropriately expressed flow rates indicated by the high volume sampler's flow rate measuring device.

14. True or False? Silica gel, calcium sulfate, and anhydrous magnesium perchlorate are common adsorbents for removing water vapor from a gas stream.

15. True or False? Artifact particulate matter formation on alkaline high volume filters is a potential source of error in high volume sampling.

16. True or False? In-situ reactions are a potential sampling problem when using bag grab sampling techniques.

17. True or False? Surface reactions at the frit are a potential sampling problem when using fritted-glass absorbers.

18. True or False? Faceplate gaskets and motor gaskets of high volume samplers need periodic replacement

19. True or False? In-situ reactions on the adsorbent during sampling and variable desorption efficiency of the adsorbate during analysis are typical adsorption air monitoring problems.

20. What is the SO_2 concentration (ppm) generated by a single dilution system if the system's undiluted SO_2 concentration is 200 ppm, the flow rate of undiluted SO_2 is 1 ℓ/min, and the flow rate of diluent gas is 19 ℓ/min?
   a. 10.0
   b. 10.5
   c. 20.0
   d. 200

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CC:434

Quiz 2

Answer Sheet

1.	a	b	c	d
2.	T	F		
3.	T	F		
4.	T	F		
5.	a	b	c	d
6.	T	F		
7.	T	F		
8.	T	F		
9.	a	b	c	d
10.	T	F		
11.	a	b	c	d
12.	T	F		
13.	T	F		
14.	T	F		
15.	T	F		
16.	T	F		
17.	T	F		
18.	T	F		
19.	T	F		
20.	a	b	c	d

I certify that this test was administered in accordance with the specified test instructions.

_____
Quiz Supervisor

7-83

CC:434

Examination 1

- This test is designed to measure whether you have mastered the objectives of the course.
- It is intended to be a ***closed-book*** exam. Do ***not*** use your notes or books. You ***may*** use a calculator.
- You will have 75 minutes to complete the test.
- On the answer sheet, circle the letter that corresponds to the best answer to each question. Each correct answer is worth two points.

1. The total required suction pressure for a pump is ____(?)____ the total pressure drop between the intake of the sample collection device and the pump's intake.
   a. equal to
   b. greater than
   c. less than

2. Which of the following has no NAAQS?
   a. nitric oxide
   b. nitrogen dioxide
   c. lead
   d. ozone

3. True or False? Thermal properties of gases affect flow rate measurements made by mass flow meters.

4. What is the SO_2 concentration (ppm) generated by a single dilution system if the system's undiluted SO_2 concentration is 100 ppm, the flow rate of undiluted SO_2 is 1 ℓ/min, and the flow rate of diluent gas is 19 ℓ/min?
   a. 90.4
   b. 5.3
   c. 5.0
   d. 100

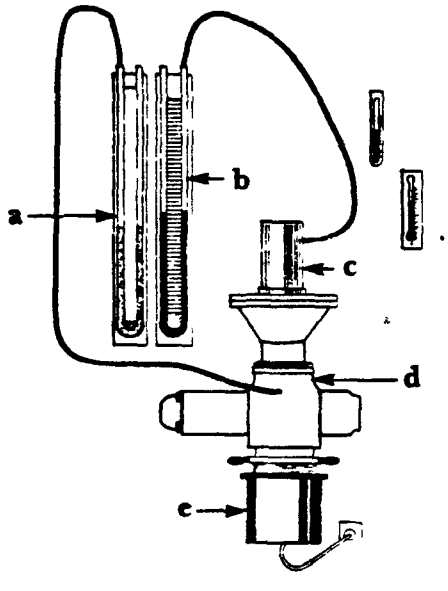
5. For a barometric pressure of 760 mm of mercury, systems having internal pressures of 770 mm and 750 mm of mercury would have gauge pressures of ____(?)____ and ____(?)____ mm of mercury respectively.
   a. 770, 750
   b. 10, −10
   c. −10, 10

6. Which of the following particle characteristics affect(s) the collection efficiency of an inertial sampling device?
   a. particle size
   b. particle density
   c. both a and b, above

7. Which of the following is a(are) potential source(s) of error in inertial sampling.
   a. particle blowing
   b. particle bounce
   c. particle re-entrainment
   d. all of the above

8. An adsorbent's collection efficiency ____(?)____ as its surface area increases.
   a. remains the same
   b. increases
   c. decreases

9. In the calibration set-up for a high volume sampler flow rate transfer standard depicted below a, b, c, d, and e are the ____(?)____ respectively.
   a. water manometer, mercury manometer, flow rate transfer standard, Roots meter, and high volume motor
   b. mercury manometer, water manometer, flow rate transfer standard, Roots meter, and high volume motor
   c. mercury manometer, water manometer, high volume motor, Roots meter, and flow rate transfer standard
   d. water manometer, mercury manometer, flow rate transfer standard, high volume motor, and Roots meter



10. 0.200 ppm of SO_2 (molecular weight: 64 g/g•mol) at EPA's STP is equal to ____(?)____ $\mu g/m^3$ of SO_2.
   a. 523
   b. 600
   c. 76.4
   d. 0.523

For each of questions 11 through 13, match the instrumental method with its advantage(s).

11. flame photometric
12. second derivative spectroscopic
13. fluorescence

a. highly specific for pollutant monitored, no support gases are needed for its operation

b. no support gases are needed for its operation, relatively insensitive to temperature and sample air flow variations

c. highly specific for sulfur compounds, no chemical solutions are needed for its operation, low maintenance requirements, high sensitivity for sulfur compounds, fast response

14. Which of the following is a(are) typical adsorption air monitoring problem(s)?
    a. irreversible adsorption of the adsorbate
    b. in-situ reactions on the adsorbent during sampling
    c. both a and b, above
    d. none of the above

15. ____(?)____ $\mu\ell$ of 100% carbon monoxide must be introduced into a 10 ℓ bag to prepare 10 ℓ of 10 ppm ($\mu\ell/\ell$) calibration gas.
    a. 0.1
    b. 100
    c 10
    d. 20

16. True or False? Regardless of its use, zero air always has the same composition.

17. The use of reference or equivalent methods is usually required
    a. when monitoring for State Implementation Plan (SIP) purposes.
    b. when monitoring for prevention of significant deterioration (PSD) purposes.
    c. for both a and b, above.
    d. for none of the above.

18. A calibration curve for a high volume sampler flow rate transfer standard is constructed by plotting ____(?)____ versus ____(?)____.
    a. standard flow rate, $\sqrt{I(P_2/P_{std})(298/T_2)}$
    b. flow rate transfer standard pressure drop, Roots meter pressure drop
    c. standard flow rate, $\sqrt{\Delta H(P_1/P_{std})(298/T_1)}$
    d. standard flow rate, indicated flow rate

19. True or False? Data should be analyzed before they are validated.

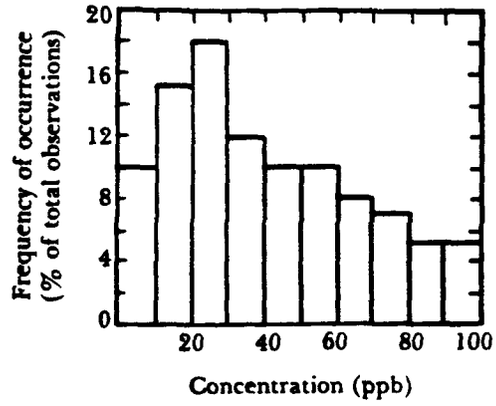
20. True or False? An air quality monitoring network needs a comprehensive quality assurance program.

For each of questions 21 through 24, match the criteria pollutant with the description of its reference method or reference measurement principle.

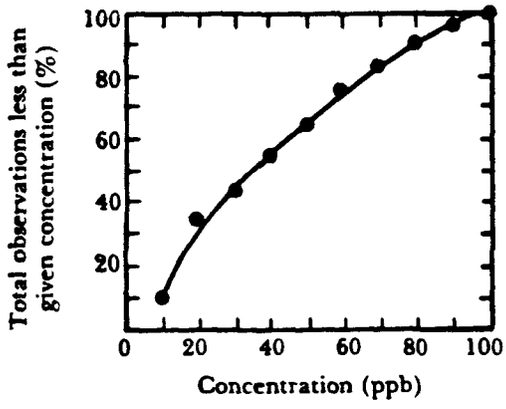
21. sulfur dioxide	a. pararosaniline method
22. nitrogen dioxide	b. chemiluminescence with ozone
23. carbon monoxide	c. chemiluminescence with ethylene
24. ozone	d. nondispersive infrared spectrometry

25. Which of the following is(are) necessary for the designation of an automated equivalent method?
    a. Performance specifications for automated methods must be met.
    b. A measurement principle different from the reference measurement principle must be used.
    c. both a and b, above
    d. none of the above

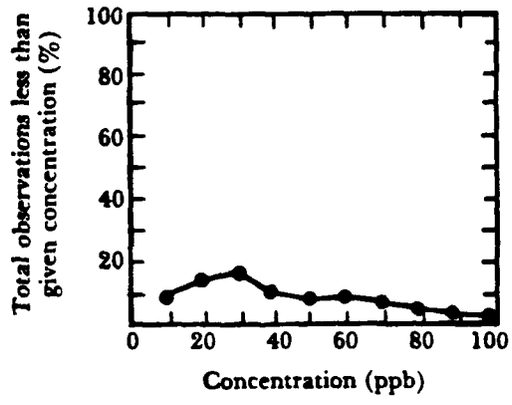
26. Which one of the following cumulative frequency distribution curves represents the data given in the histogram below?



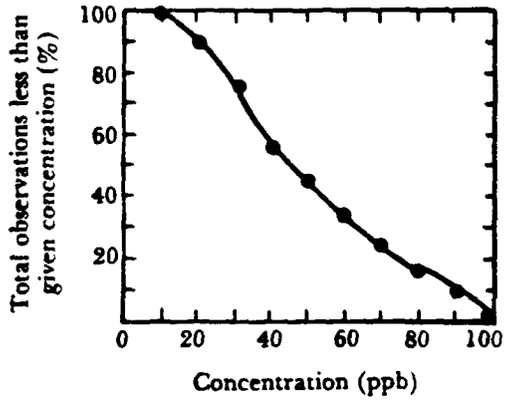
a.



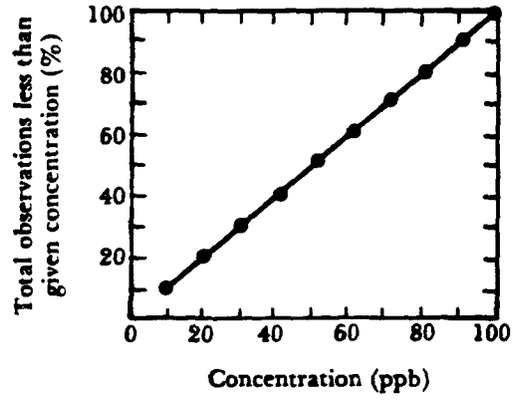
b.



c.



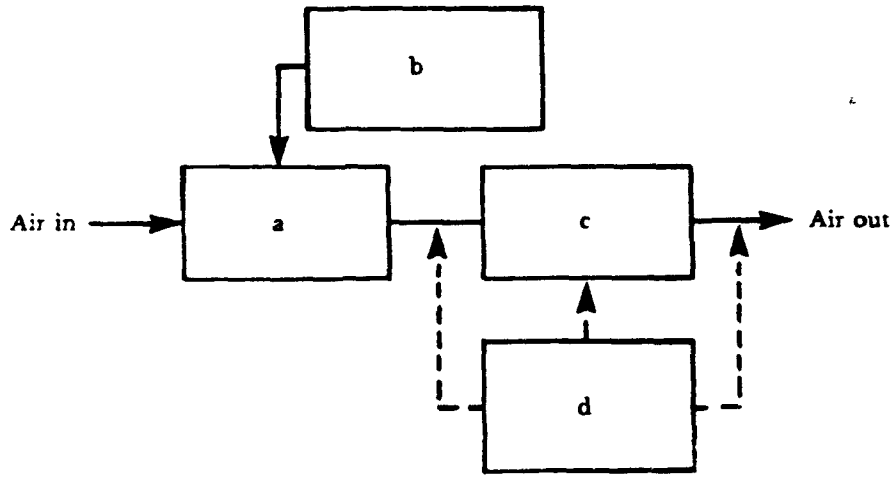
d.



27. The geometric mean of a log normally distributed data set gives ____(?)____ measure of the data set's central location as(than does) the data set's arithmetic mean.
    a. the same
    b. a more accurate
    c. a less accurate

28. Which of the following is a(are) possible objective(s) of ambient air quality monitoring?
    a. Establish baseline air quality levels for preventing the significant deterioration of air quality.
    b. Provide data for the development/validation of in-situ stack emission monitors.
    c. Provide data for initiating reductions of emissions during air pollution emergency episodes.
    d. both a and c, above

29. In the typical sampling train depicted below; a, b, c, and d are the ____(?)____ respectively.
    a. flow measuring device, sample collection device, air mover, and contaminant detector
    b. sample collection device, contaminant detector, air mover, and flow measuring device
    c. air mover, sample collection device, sample manifold, and contaminant detector
    d. sample collection device, sample manifold, air mover, and flow measuring device



30. Which of the following equations is used to correct flow rates measured by rate meters to EPA's STP conditions?

a. $Q_2 = Q_1 \left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$

b. $Q_2 = Q_1 \left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$

c. $Q_2 = Q_1 \left[\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

d. $Q_2 = Q_1 \left[\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

Where: Q_2 = corrected flow rate at EPA's STP conditions
Q_1 = measured flow rate at P_1 and T_1
T_1 = measured temperature of gas, K
T_2 = 298 K
P_1 = measured pressure of gas, mm Hg
P_2 = 760 mm Hg

31. 50 degrees Fahrenheit equals ____(?)____ degrees Celsius.
a. 10
b. 122
c. −4.2
d. 15.3

32. Which one of the following equations is the most accurate and easiest to use for calculating standard geometric deviation?

a. $\sqrt{\frac{\Sigma(X_i - \overline{X})^2}{n-1}}$

b. $\sqrt{\frac{n\Sigma X_i^2 - (\Sigma X_i)^2}{n(n-1)}}$

c. antilog $\left[\frac{\Sigma(\log X - \overline{\log X})^2}{n-1}\right]^{1/2}$

d. antilog $\left[\frac{\Sigma(\log X)^2 - \frac{(\Sigma \log X)^2}{n}}{n-1}\right]^{1/2}$

Where: X_i = a data value
$\overline{X}$ = the mean of the data sample
n = the number of observations

33. True or False? Blank concentrations of pollutants in clean glass fiber filters should be taken into account when analyzing exposed filters for pollutants.

34. True or False? Particle size and density affect the collection efficiency of an inertial sampling device.

35. Under the conditions described below, the suspended particulate concentration obtained using a high volume sampler is ____(?)____ $\mu g/std\ m^3$.
    a. 250
    b. 235
    c. 100
    d. 268

    Given: Weight of filter after sampling: 3.540 g
    Weight of filter before sampling: 3.000 g
    Initial sampling flow rate: 1.60 std m^3/min
    Final sampling flow rate: 1.40 std m^3/min
    Sampling period: midnight 7-11-81 to midnight 7-12-81

36. At constant temperature, the volume of a gas ____(?)____ as the pressure exerted on it ____(?)____.
    a. decreases, increases
    b. decreases, decreases
    c. increases, increases

37. ____(?)____ standard meters are those calibrated against ____(?)____ or ____(?)____ standard meters. Accuracies better than 5% can be achieved.
    a. Secondary, primary, intermediate
    b. Intermediate, primary, secondary
    c. Primary, intermediate, secondary

38. Which of the following equations is used to correct air volumes sampled to EPA's STP conditions?

    a. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$

    b. $V_2 = (V_1)\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$

    c. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_1}{T_2}\right)$

    d. $V_2 = (V_1)\left(\frac{P_1}{T_1}\right)\left(\frac{P_2}{T_2}\right)$

    Where: V_2 = corrected volume of air at P_2 and T_2, ℓ
    V_1 = initial volume of air at P_1 and T_1, ℓ
    T_1 = initial temperature of air, K
    T_2 = 298 K
    P_1 = initial pressure of air, mm Hg
    P_2 = 760 mm Hg

39. A calibration curve for a high volume sampler flow rate measuring device is constructed by plotting ____(?)____ versus ____(?)____.
    a. standard flow rates, appropriately expressed flow rates indicated by the high volume sampler's flow rate measuring device
    b. flow rate transfer standard pressure drops, appropriately expressed flow rates indicated by the high volume sampler's flow rate measuring device
    c. standard flow rates, flow rate transfer standard pressure drops

40. Particle re-entrainment ____(?)____ as the filter face velocity increases.
    a. remains the same
    b. increases
    c. decreases

41. True or False? The absorption of acid gases by glass fiber filters can be minimized by using glass fiber filters which have a neutral pH.

42. Which of the following should be considered when choosing an absorbent for a chemical absorption pollutant sampling process?
    a. pollutant solubility in absorbent
    b. reactive properties of the pollutant and the absorbent
    c. method of pollutant analysis
    d. all of the above

43. True or False? A critical orifice is an orifice meter having a pressure drop such that any further decrease in its downstream pressure or increase in its upstream pressure will not change the gas flow rate through it.

44. Which of the following is a(are) disadvantage(s) of fritted-glass absorbers?
    a. possibility of surface reactions at the frit
    b. fritted-glass absorbers having frit pore sizes of approximately 50 μm or less gradually become clogged with use
    c. both a and b, above
    d. none of the above

45. ____(?)____ meters measure the total ____(?)____ of gas passed through them over some specified time period.
    a. Volume, volume
    b. Rate, rate
    c. Velocity, velocity

46. True or False? A mass flow meter works on the principle that as a gas passes over a heated surface, heat is transferred from the surface to the gas. The amount of current required to keep the surface at a constant temperature is a measure of the velocity of the gas.

47. Neighborhood scale measurements are associated with ambient air volumes with dimensions ranging from ____(?)____ kilometer(s).
    a. 4 to 50
    b. 5 to 10
    c. 0.1 to 0.5
    d. 0.5 to 4

48. True or False? Before designing an air quality monitoring network, the uses of the data that will be generated by the network should be established.

49. True or False? The SAROAD data format is available from EPA.

50. True or False? Data validation should be performed as closely as possible in place and time to the collection of the data.

Name _____

Date _____

CC:434

Examination 1

Answer Sheet

(1.)	a	b	c	
(2.)	a	b	c	d
(3.)	T	F		
4.	a	b	c	d
(5.)	a	b	c	
(6.)	a	b	c	
(7.)	a	b	c	d
8.	a	b	c	
9.	a	b	c	d
(10.)	a	b	c	d
11.	a	b	c	
12.	a	b	c	
13.	a	b	c	
14.	a	b	c	d
15.	a	b	c	d
16.	T	F		
17.	a	b	c	d
18.	a	b	c	d
19.	T	F		
20.	T	F		
21.	a	b	c	d
22.	a	b	c	d
23.	a	b	c	d
24.	a	b	c	d
25.	a	b	c	d

(Please Print)

Address:

_____

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(26.)	a	b	c	d
(27.)	a	b	c	d
(28.)	a	b	c	d
(29.)	a	b	c	d
(30.)	a	b	c	d
(31.)	a	b	c	d
(32.)	a	b	c	d
33.	T	F		
(34.)	T	F		
35.	a	b	c	d
(36.)	a	b	c	
(37.)	a	b	c	
(38.)	a	b	c	
39.	a	b	c	
40.	a	b	c	
41.	T	F		
42.	a	b	c	d
(43.)	T	F		
44.	a	b	c	d
(45.)	a	b	c	
(46.)	T	F		
47.	a	b	c	d
48.	T	F		
49.	T	F		
50.	T	F		

I certify that this test was administered in accordance with the specified test instructions.

_____

Test Supervisor

Note: Questions having circled numbers test objectives of Part A (Sections A-1 through A-4) of the course.

7-83

Section A-1

Introduction to Atmospheric Sampling and Basic Properties of Gases

Reading Assignment

Pages 1-1 through 2-34 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Objectives of air monitoring
- Sampling train design
- Temperature and pressure measurement
- Ideal Gas Law
- Gas density and viscosity
- Units of measurement
- Air monitoring terminology

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with objectives of air monitoring, air monitoring terminology, sampling train design, and basic properties of gases.

Learning Objectives

At the end of this section, you should be able to:

1. state the purposes of primary and secondary National Ambient Air Quality Standards (NAAQS) and identify the pollutants for which NAAQS have been established.
2. identify at least six objectives of ambient air quality monitoring.
3. identify the locations of sampling train components in a typical sampling train.
4. identify four temperature scales used in atmospheric sampling and convert temperatures from one scale to another.
5. define pressure terms used in atmospheric sampling.
6. describe pressure measuring devices used in ambient air quality monitoring.
7. explain the effects of temperature and pressure on sampled air volumes.

8. correct sampled air volumes to EPA's Standard Temperature and Pressure (STP) conditions for ambient air monitoring.
9. define the following gas characteristics: density, viscosity, molar volume, specific gravity, and Reynold's number.
10. report values commonly measured in ambient air sampling using their appropriate reporting units.
11. convert between pollutant concentrations expressed in parts per million (ppm) and those expressed in micrograms per cubic meter ($\mu g/m^3$).

Reading Guidance

- Refer often to the equations, example calculations, and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section A-1. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any), proceed to Section A-2 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section A-1, please answer the following questions. These will help you determine whether or not you are mastering the material. Please do not write in this guidebook.

1. National Ambient Air Quality Standards (NAAQS) have been established for which of the following?
   a. sulfur dioxide
   b. total suspended particulate matter
   c. mercury
   d. both a and c, above
   e. both a and b, above

2. Which of the following has no NAAQS?
   a. nitric oxide
   b. nitrogen dioxide
   c. lead
   d. ozone

3. Primary NAAQS are established to protect public ____(?)____.
   a. health
   b. welfare
   c. health and welfare
   d. none of the above

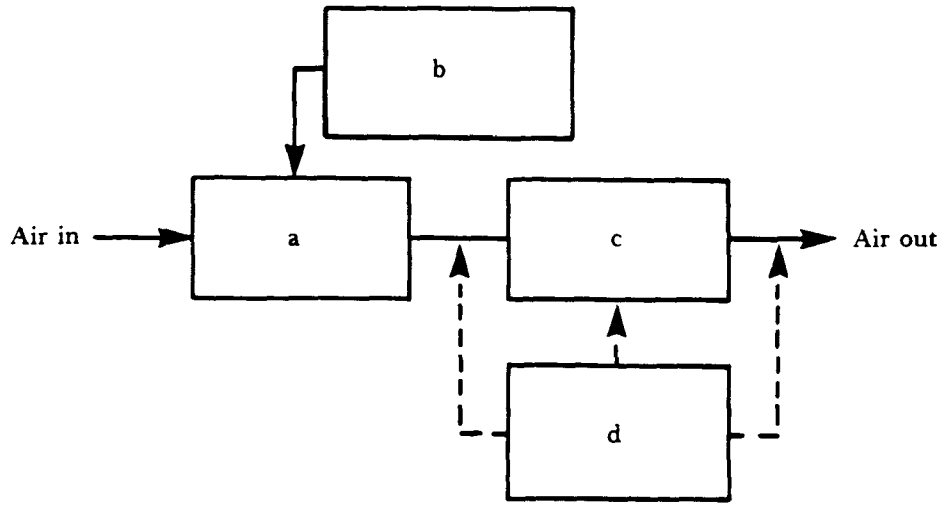
4. Secondary NAAQS are established to protect public ____(?)____.
   a. health
   b. welfare
   c. health and welfare
   d. none of the above

5. True or False? State implementation plans (SIPs) are air pollution control strategies used by the States to attain and maintain the NAAQS.

6. Which of the following is ***not*** a possible objective of ambient air quality monitoring?
   a. determine attainment of NAAQS
   b. evaluate progress in achieving/maintaining NAAQS
   c. develop or revise SIPs
   d. review air quality impacts of new sources of air pollution
   e. determine emission rates of pollutants from stacks

7. Which of the following is a(are) possible objective(s) of ambient air quality monitoring?
   a. establish baseline air quality levels for preventing the significant deterioration of air quality
   b. provide data for the development/validation of air pollution dispersion models
   c. provide data for the development/validation of in-situ stack emission monitors
   d. both a and b, above
   e. all of the above

8. In the typical sampling train depicted below, a, b, c, and d are the ____(?)____ respectively.
   a. flow measuring device, sample collection device, air mover, and contaminant detector
   b. sample collection device, contaminant detector, air mover, and flow measuring device
   c. air mover, sample collection device, sample manifold, and contaminant detector
   d. sample collection device, sample manifold, air mover, and flow measuring device



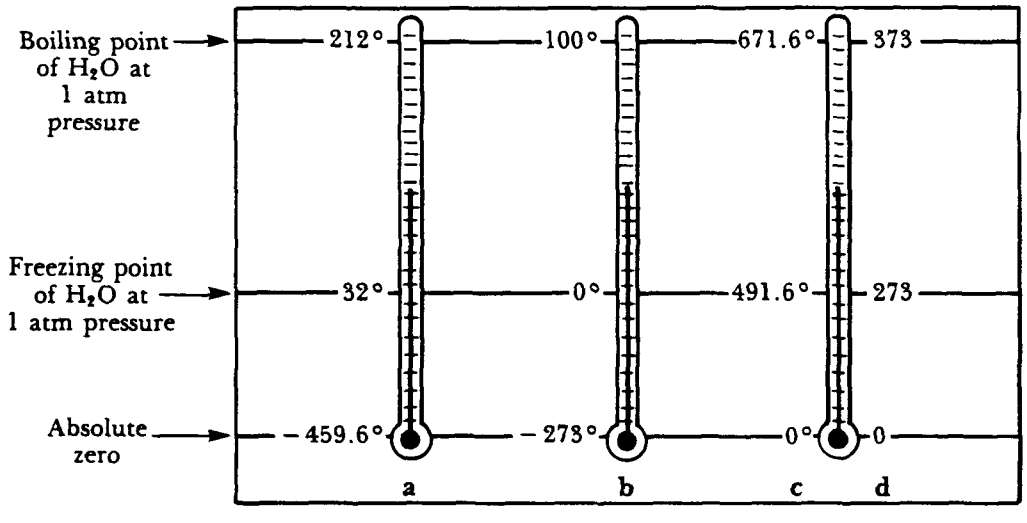
9. In air sampling trains, air movers and flow measuring devices should be placed ____(?)____ sample collection devices to avoid contamination of the sample air stream.
   a. downstream of
   b. upstream of
   c. at the same location as

10. In an air sampling train, inert materials should be used ____(?)____ of the sample collection device to avoid contamination/loss of the pollutant being sampled.
    a. downstream
    b. upstream
    c. upstream and downstream

11. True or False? Use of long sampling lines should be avoided because they enhance the possible sampling line wall loss of sample pollutant.

12. True or False? Components of air sampling trains must be protected from damage caused by sampled air and products of the measurement system.

13. In the figure below, a, b, c, and d are the ____(?)____ temperature scales respectively.
    a. Fahrenheit, Celsius, Rankine, and kelvin
    b. Celsius, Fahrenheit, kelvin, and Rankine
    c. kelvin, Fahrenheit, Celsius, and Rankine
    d. Rankine, Fahrenheit, kelvin, and Celsius



14. 68 degrees Fahrenheit equals ____(?)____ degrees Celsius.
    a. 38
    b. 6
    c. 20
    d. 25

15. 10 degrees Celsius equals ____(?)____ degrees Fahrenheit.
    a. 50
    b. −14
    c. 32
    d. 65

16. 25 degrees Celsius equals ____(?)____ kelvin.
    a. 248
    b. 273
    c. 298
    d. 312

17. 25 degrees Fahrenheit equals ____(?)____ degrees Rankine.
    a. 460
    b. 435
    c. 550
    d. 485

18. The temperature at which a gas, if it did not condense, would theoretically have a volume of zero is called ____(?)____.
    a. critical temperature
    b. dew point temperature
    c. absolute zero

19. Absolute zero is equal to ____(?)____ degrees Celsius and ____(?)____ degrees Fahrenheit.
    a. 273, 460
    b. −273, −460
    c. −460, −273
    d. 460, 273

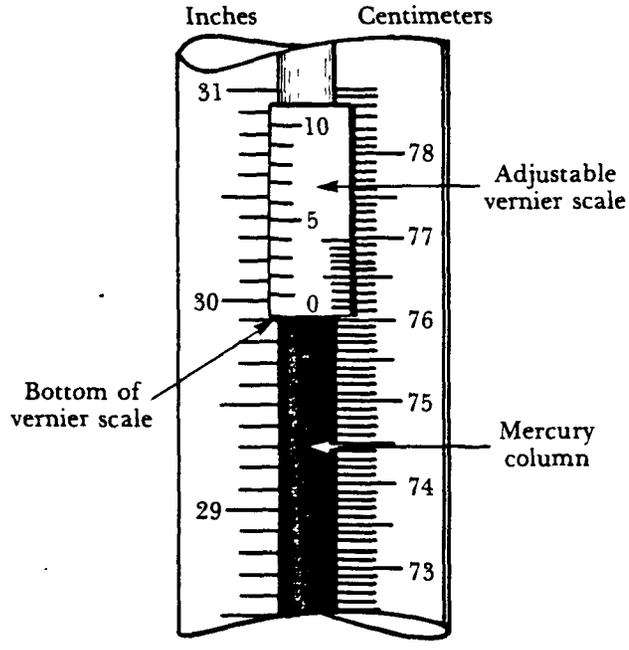
20. Pressure is expressed as ____(?)____ per unit ____(?)____.
    a. force, area
    b. force, volume
    c. area, force
    d. volume, force

21. Pressure is equal in ____(?)____ directions at a point within a volume of fluid and acts ____(?)____ to a surface.
    a. some, perpendicular
    b. all, horizontal
    c. all, perpendicular
    d. some, horizontal

22. The height of the mercury column in a Fortin barometer is measured from the ____(?)____ of the ivory index point to the ____(?)____ of the mercury column.
    a. middle, top
    b. tip, top
    c. tip, middle
    d. middle, middle

23. Before measuring barometric pressure using a Fortin barometer, the mercury level in the barometer's cistern is adjusted until the ivory index point ____(?)____ the surface of the mercury.
    a. is completely under
    b. is halfway below
    c. just pricks

24. The barometer scale depicted below indicates a barometric pressure of ____(?)____ cm of mercury.
    a. 29.94
    b. 76.50
    c. 76.00
    d. 76.05



25. Aneroid barometers are usually ____(?)____ as(than) Torricelli-type barometers.
    a. not as accurate
    b. as accurate
    c. more accurate

26. For a barometric pressure of 760 mm of mercury, systems having internal pressures of 770 mm and 750 mm of mercury would have gage pressures of ____(?)____ and ____(?)____ mm of mercury respectively.
    a. 770, 750
    b. 10, −10
    c. −10, 10

27. True or False? The total pressure of a gas mixture is the sum of its partial pressures.

28. At constant temperature, the volume of a gas ____(?)____ as the pressure exerted on it ____(?)____.
    a. decreases, increases
    b. decreases, decreases
    c. increases, increases

29. At constant pressure, the volume of a gas ____(?)____ as the temperature of the gas ____(?)____.
    a. decreases, increases
    b. increases, decreases
    c. increases, increases

30. EPA's standard temperature and pressure (STP) conditions for ambient air monitoring are ____(?)____ degrees Celsius and ____(?)____ mm of mercury.
    a. 20, 760
    b. 25, 760
    c. 25, 700
    d. 20, 700

31. Molar volume at EPA's STP conditions is ____(?)____ liters.
    a. 22.41
    b. 24.46
    c. 20.08
    d. 26.35

32. The density of sulfur dioxide (molecular weight: 64 g/g•mol) at EPA's STP conditions is ____(?)____ g/ℓ.
    a. 2.6
    b. 1.0
    c. 16.3
    d. 46.2

33. Which of the following equations is used to correct air volumes sampled to EPA's STP conditions?
    a. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$
    b. $V_2 = (V_1)\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$
    c. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_1}{T_2}\right)$
    d. $V_2 = (V_1)\left(\frac{P_1}{T_1}\right)\left(\frac{P_2}{T_2}\right)$

    Where: V_2 = corrected volume of air at P_2 and T_2, ℓ
    V_1 = initial volume of air at P_1 and T_1, ℓ
    T_1 = initial temperature of air, K
    T_2 = 298 K
    P_1 = initial pressure of air, mm Hg
    P_2 = 760 mm Hg

34. The viscosity of a gas ____(?)____ as the temperature of the gas ____(?)____.
    a. increases, increases
    b. increases, decreases
    c. decreases, increases

35. The ____(?)____ the Reynold's number, the ____(?)____ is the effect of viscous forces.
    a. smaller, smaller
    b. larger, smaller
    c. larger, larger

36. Which of the following should be considered when reporting measured pollutant concentrations?
    a. Ideally, units reported should be the same as units measured.
    b. Should avoid multiplying measured values by larger numbers for extrapolation purposes.
    c. When air volumes are sampled, sampling temperature and pressure should be reported.
    d. all of the above

For each of questions 37 through 42, select the preferred reporting unit for each of the following parameters.

37. particulate pollutant concentration
38. gaseous pollutant concentration
39. temperature
40. time
41. pressure
42. air sampling rate

a. $\mu g/m^3$ at EPA's STP
b. ppm/ppb
c. degrees Fahrenheit
d. degrees Celsius
e. inches of mercury
f. mm of mercury
g. 12:00 am to 12:00 pm
h. 0000 to 2400
i. m^3/min
j. ft^3/min

43. 0.489 ppm of SO_2 (molecular weight: 64 g/g•mol) at EPA's STP is equal to ____(?)____ $\mu g/m^3$ of SO_2.
    a. 1,400
    b. 1.28
    c. 187
    d. 1,280

44. 640 $\mu g/m^3$ of SO_2 (molecular weight: 64 g/g•mol) at EPA's STP is equal to ____(?)____ ppm of SO_2.
    a. 0.245
    b. 245
    c. 1.67
    d. 16.7

For each of questions 45 through 57, match the term with its definition.

45. pressure
46. absolute pressure
47. pressure-head
48. partial pressure
49. density
50. viscosity
51. laminar flow
52. turbulent flow
53. specific gravity
54. Reynold's number
55. standard barometric pressure
56. molar volume
57. efficiency

a. resistance to flow
b. mass per volume
c. unit compressive stress in a fluid
d. the sum of barometric pressure and gauge pressure
e. pressure exerted by one component of a gas mixture
f. the height of a column of fluid required to produce a given pressure at its base
g. $\frac{\text{inertial force of a fluid}}{\text{viscous force of a fluid}}$
h. parallel movement of fluid layers
i. $\frac{\text{attained performance}}{\text{absolute performance}}$
j. haphazard movement of fluid
k. $\frac{\text{density of a substance}}{\text{density of a reference substance}}$
l. the average atmospheric pressure at sea level, 45° north latitude, and 35 degrees Fahrenheit; equivalent to a pressure of 1033.23 grams-force per cm^2 exerted at the base of a column of mercury having a height of 760 mm
m. the volume of one mole of a gas at a specified temperature and pressure

58. A barograph is the combination of a(n) ____(?)____ and a(n) ____(?)____.
    a. aneroid barometer, Fortin barometer
    b. aneroid barometer, automatic recording device
    c. Fortin barometer, automatic recording device

59. Ideal gases are gases whose molecules ____(?)____ one another and which occupy ____(?)____.
    a. do not attract, no space
    b. do not attract, space
    c. attract, no space
    d. attract, space

60. A mole of a substance is the substance's ____(?)____ expressed in mass units.
    a. density
    b. atomic number
    c. molecular weight
    d. viscosity

Section A-1
Review Exercise Answers

		Page(s) of *Atmospheric Sampling: Student Manual*
1.	e	1-1
2.	a	1-1
3.	a	1-1
4.	b	1-1
5.	True	1-1
6.	e	1-1, 1-2
7.	d	1-1, 1-2
8.	b	1-3
9.	a	1-4
10.	b	1-4
11.	True	1-4
12.	True	1-4
13.	a	2-2
14.	c	2-1
15.	a	2-1
16.	c	2-1
17.	d	2-1
18.	c	2-1
19.	b	2-1
20.	a	2-3
21.	c	2-3
22.	b	2-5
23.	c	2-5
24.	d	2-6
25.	a	2-6
26.	b	2-9
27.	True	2-11
28.	a	2-12
29.	c	2-12
30.	b	2-15
31.	b	2-14
32.	a	2-14
33.	a	2-15
34.	a	2-17
35.	b	2-18
36.	d	2-22
37.	a	2-23
38.	b	2-23

	Page(s) of *Atmospheric Sampling: Student Manual*
39. d	2-23
40. h	2-23
41. f	2-24
42. i	2-24
43. d	2-24, 2-25
44. a	2-24, 2-25
45. c	2-3
46. d	2-9
47. f	2-11
48. e	2-11
49. b	2-14
50. a	2-15
51. h	2-20
52. j	2-20
53. k	2-33
54. g	2-17
55. l	2-3
56. m	2-14
57. i	2-28
58. b	2-7
59. a	2-12
60. c	2-13

Section A-2

Air Movers and Air Measuring Instruments

Reading Assignment

Pages 3-1 through 3-50 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Air movers
- Air measuring instruments

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with air movers and air measuring instruments.

Learning Objectives

At the end of this section, you should be able to:

1. recognize at least six considerations in selecting an air mover for atmospheric sampling.
2. recognize at least three evaluation criteria for determining the ease of maintenance of an air mover.
3. identify piston, diaphragm, and centrifugal pumps from their diagrams.
4. recognize the effects of sample flow rate and pressure drop on the performance of air sampling pumps.
5. calculate the volume of air sampled by ambient air quality sampling trains.
6. describe the 13 air measuring devices discussed in this section and classify them according to air measuring device category and standard meter class.
7. name at least four air movers that are used in atmospheric sampling.
8. calculate the required sampling flow rate for a given atmospheric sampling situation.
9. identify a critical orifice calibration curve.
10. recognize equations used to correct measured flow rates and air volumes to EPA's Standard Temperature and Pressure (STP) conditions.
11. recognize that gas density has an effect on flow rate measurements made by rotameters.

12. recognize the effects of gas temperature, pressure, and thermal properties on flow rate measurements made by mass flow meters.
13. name at least two advantages of a dry test meter over a wet test meter.
14. recognize at least two methods of maintaining a constant sampling flow rate through a sampling train.
15. recognize the path of sample air flow through an ejector.
16. identify at least four sources of pressure drop in a typical sampling train.

Reading Guidance

- The calibration of flow measuring devices is discussed in this reading assignment. EPA will verify the calibration of your flow measuring devices at no cost to you. If you would like to use this service, contact: U.S. EPA, Quality Assurance Division, Standards Laboratory, EMSL, MD 77, Research Triangle Park, North Carolina 27711 (telephone: Commercial: (919) 541-2366, FTS: 629-2366).
- Refer often to the equations, example calculations, and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section A-2. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any), proceed to Section A-3 of this guidebook.

Review Exercise

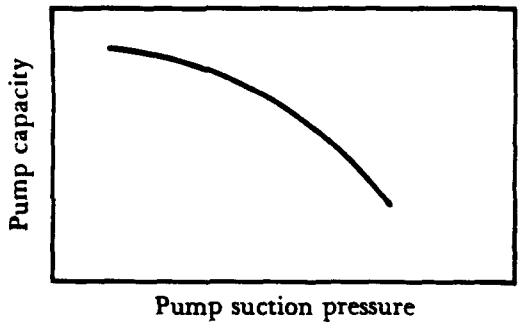
Now that you've completed the assignment for Section A-2, please answer the following questions. These will help you determine whether or not you are mastering the material.

1. True or False? The primary purpose of an air mover in the air sampling process is to create a flow of air that will allow the pollutant of interest in the air to be analyzed directly or to be collected for subsequent analysis.
2. Which of the following is ***not*** a possible consideration in selecting an air mover for atmospheric sampling?
   a. sampling flow rate
   b. physical/chemical nature of the air to be sampled
   c. portability of the air mover
   d. noise of the air mover
   e. ease of maintenance of the air mover
   f. resistance to sample air flow by the collection device
   g. none of the above
3. A sampling flow rate of at least ___(?)___ m^3/h is required if the available sampling time is 5 hours, the analytical method is accurate only for samples which contain at least 10 μg of the pollutant, and the air sample is expected to contain at least 1 $\mu g/m^3$ of the pollutant.
   a. 0.5
   b. 1
   c. 2
   d. 10
4. Which of the following should be considered in evaluating the ease of maintenance of an air mover?
   a. accessibility of repair parts
   b. sampling flow rate
   c. cost of repair parts
   d. both a and c, above
   e. all of the above
5. In general, ___(?)___ preventive maintenance activities ___(?)___ air mover malfunctions.
   a. increasing, increases
   b. decreasing, decreases
   c. increasing, decreases

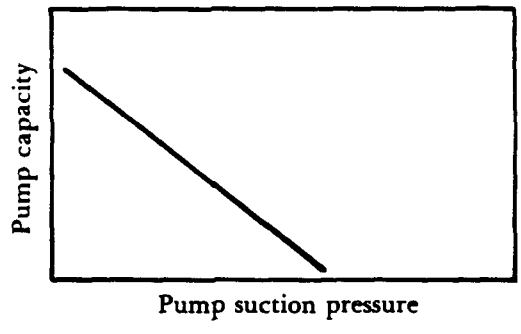
For each of questions 6 and 7, match the general pump with its appropriate relationship between pump capacity and pump suction pressure.

6. positive displacement
7. centrifugal

a.



b.

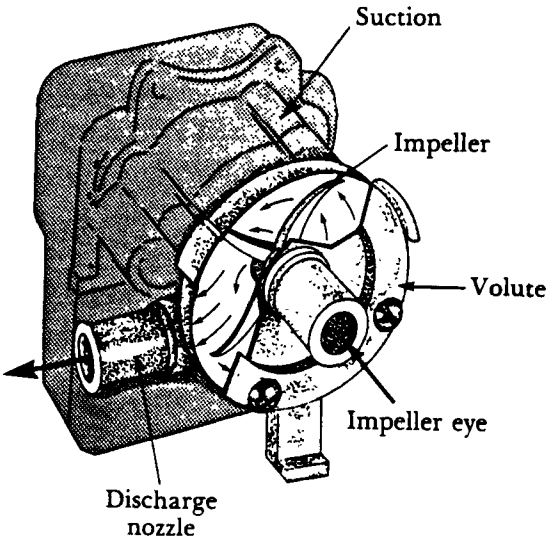


8. Piston and diaphragm pumps are ____(?)____ pumps.
   a. centrifugal
   b. radial flow
   c. axial flow
   d. positive displacement

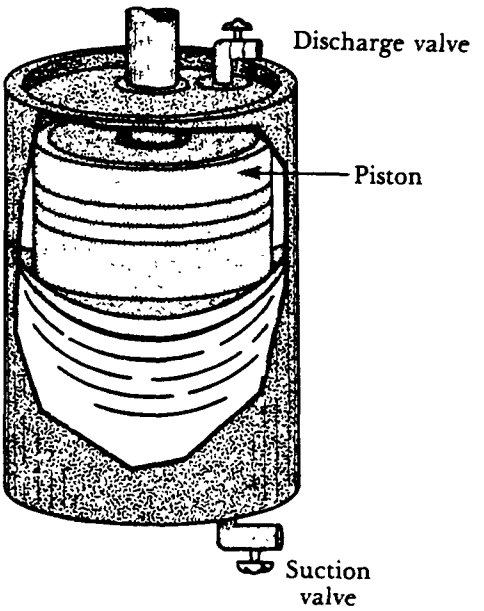
For each of questions 9 through 11, match the pump with its appropriate diagram.

9. piston pump
10. diaphragm pump
11. centrifugal pump

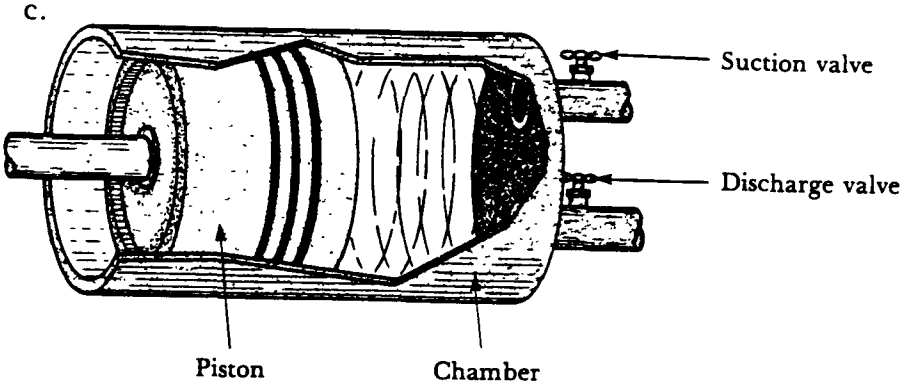
a.



b.



c.

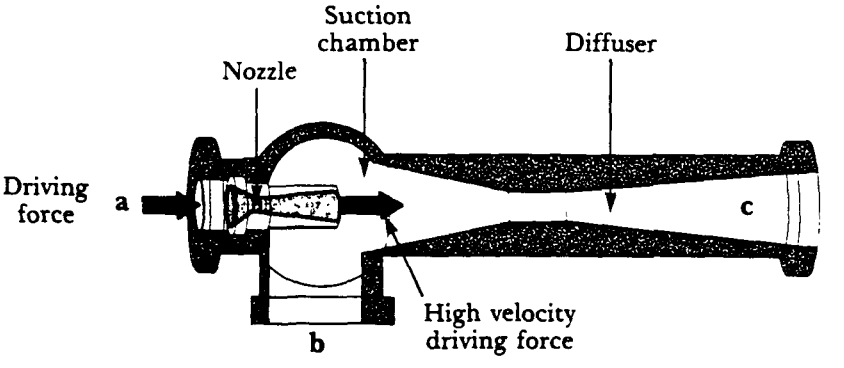


12. True or False? Variations of the driving force of a pump have no effect on the pump's sampling flow rate.

13. The total required suction pressure for a pump is ____(?)____ the total pressure drop between the intake of the sample collection device and the pump's intake.
    a. equal to
    b. greater than
    c. less than

14. True or False? Properly calibrated pump pressure gauges can be used for approximating flow rates through pumps.

15. In the ejector diagram below, sample air enters at ____(?)____ and leaves at ____(?)____.
    a. a,b
    b. a,c
    c. b,a
    d. b,c
    e. c,b



16. True or False? Evacuated flasks and containers which are filled with liquids can be used as air movers.

17. Which of the following is ***not*** a(are ***not***) method(s) for controlling sample air flow rate?
    a. diversion
    b. resistance
    c. control of air mover's driving force
    d. modulation
    e. all of the above

18. Generally, air mover flow rate ____(?)____ as the sampling train's resistance to flow ____(?)____.
    a. increases, increases
    b. decreases, increases
    c. decreases, decreases

19. True or False? The collection efficiency of an air sampling device may be affected by fluctuations in sampling flow rate.

20. Which of the following is ***not*** a source of pressure drop in a typical sampling train?
    a. sample collection device
    b. flow measuring device
    c. flow regulator
    d. connecting lines
    e. none of the above

21. A constant sampling flow rate can be maintained through a sampling train by either ____(?)____ the flow regulator's resistance to flow or ____(?)____ the pump's motor speed.
    a. increasing, increasing
    b. increasing, decreasing
    c. decreasing, increasing
    d. decreasing, decreasing

22. True or False? Measurement of the volume of air sampled affects the accuracy and precision of the pollutant concentration determination.

23. Which of the following equations is appropriate for calculating the volume of air sampled?
    a. $V = \frac{Q}{t}$
    b. $V = \frac{t}{Q}$
    c. $V = \left(\frac{Q}{t}\right)Q$
    d. $V = (Q)(t)$

    Where: V = volume of air sampled
    Q = sampling flow rate
    t = sampling time

24. Which of the following is ***not*** a(are ***not***) category(ies) of air measuring devices?
    a. volume meters
    b. rate meters
    c. velocity meters
    d. centrifugal meters
    e. all of the above

25. ____(?)____ meters measure the total ____(?)____ of gas passed through them over some specified time period.
    a. Volume, volume
    b. Rate, rate
    c. Velocity, velocity

26. ____(?)____ meters measure the time ____(?)____ of flow through them.
    a. Volume, volume
    b. Rate, rate
    c. Velocity, velocity

27. ____(?)____ meters measure the linear ____(?)____ of a gas in a duct.
    a. Volume, volume
    b. Rate, rate
    c. Velocity, velocity

28. True or False? Measurement of sampling flow rate and sampling time affects the determination of the volume of air sampled.

29. Which of the following is ***not*** a(are not) type(s) of standard meters used to calibrate air measuring devices?
    a. primary standard meters
    b. intermediate standard meters
    c. secondary standard meters
    d. tertiary standard meters
    e. all of the above

30. ____(?)____ standard meters are those whose volumes can be determined by measurement of internal physical dimensions alone. Accuracies better than ±0.30% can be achieved.
    a. Primary
    b. Intermediate
    c. Secondary

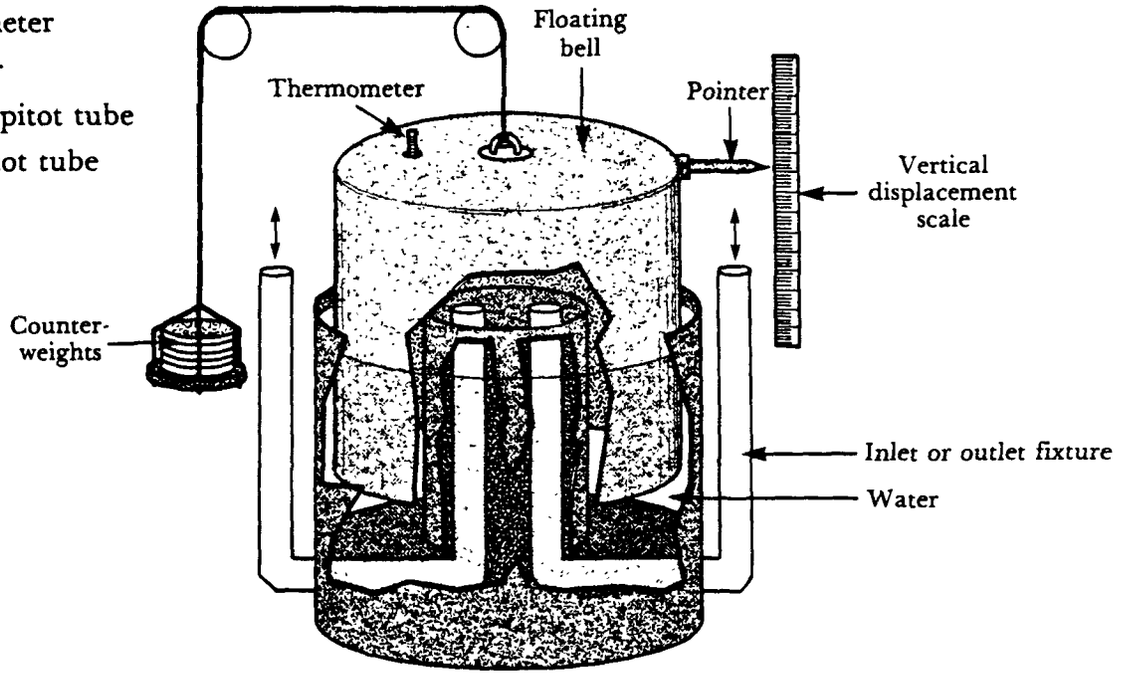
31. ____(?)____ standard meters are those that cannot easily be calibrated by measuring physical dimensions, but can achieve accuracies of ±1 to 2%.
    a. Primary
    b. Intermediate
    c. Secondary

32. ____(?)____ standard meters are those calibrated against ____(?)____ or ____(?)____ standard meters. Accuracies better than 5% can be achieved.
    a. Secondary, primary, intermediate
    b. Intermediate, primary, secondary
    c. Primary, intermediate, secondary

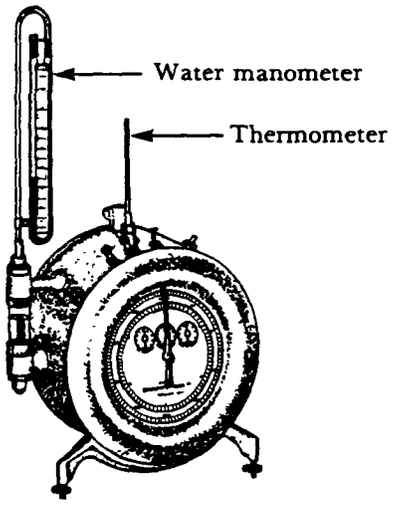
For each of questions 33 through 44, match the air measuring device with its appropriate diagram.

33. spirometer
34. displacement bottle technique
35. soap bubble meter
36. mercury-sealed piston
37. wet test meter
38. Roots meter
39. dry test meter
40. orifice meter
41. venturi meter
42. rotameter
43. standard pitot tube
44. S-type pitot tube

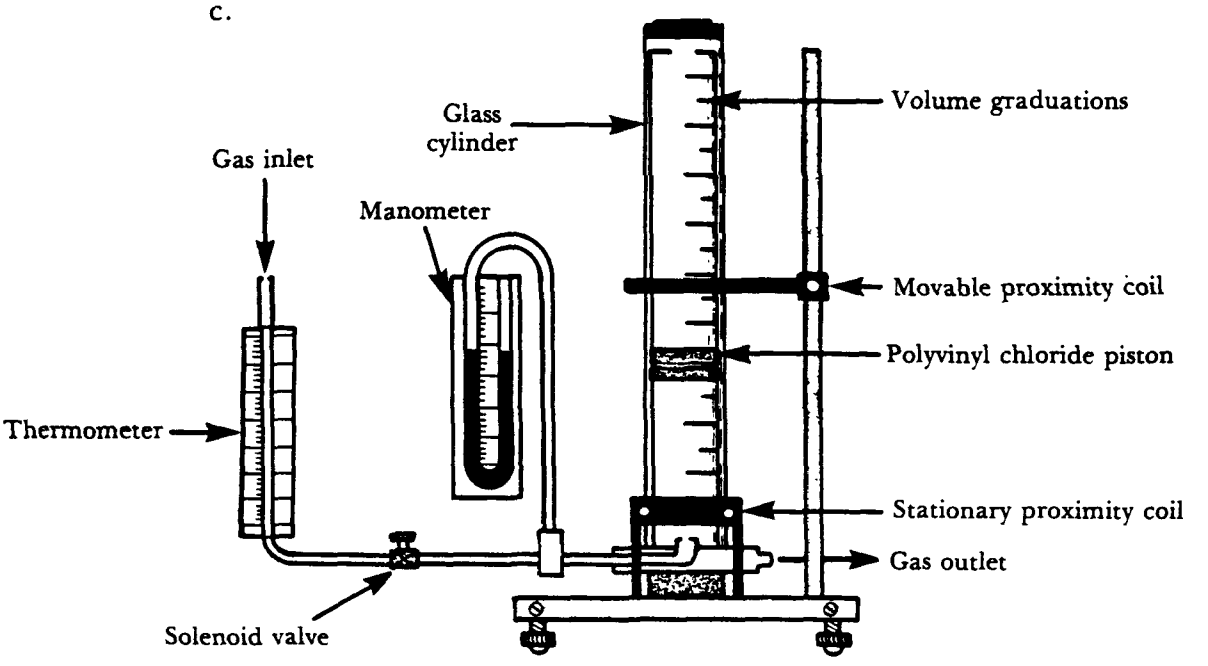
a.



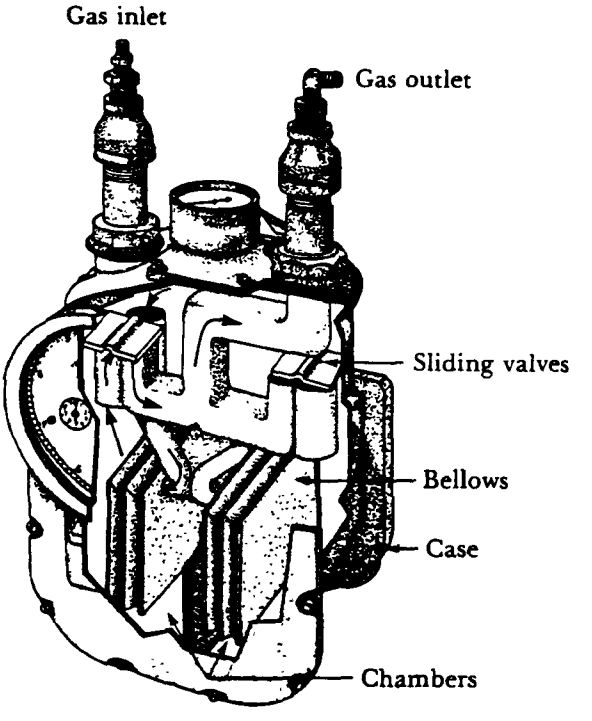
b.



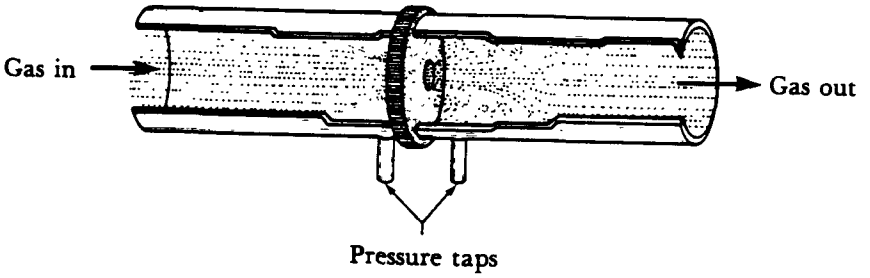
c.


Glass cylinder
Volume graduations
Gas inlet
Manometer
Movable proximity coil
Polyvinyl chloride piston
Thermometer
Stationary proximity coil
Gas outlet
Solenoid valve

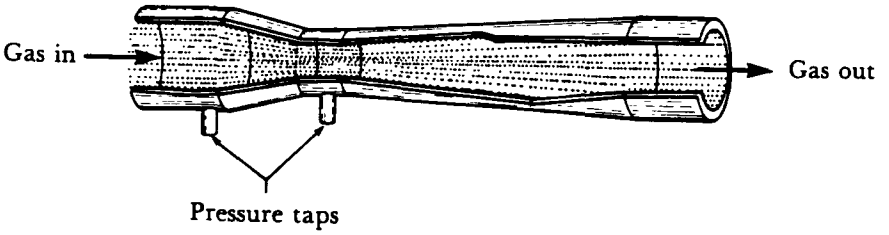
d.


Gas inlet
Gas outlet
Sliding valves
Bellows
Case
Chambers

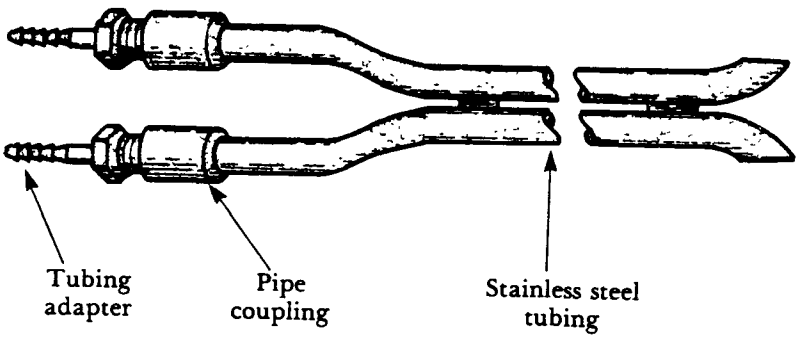
e.


Gas in
Gas out
Pressure taps

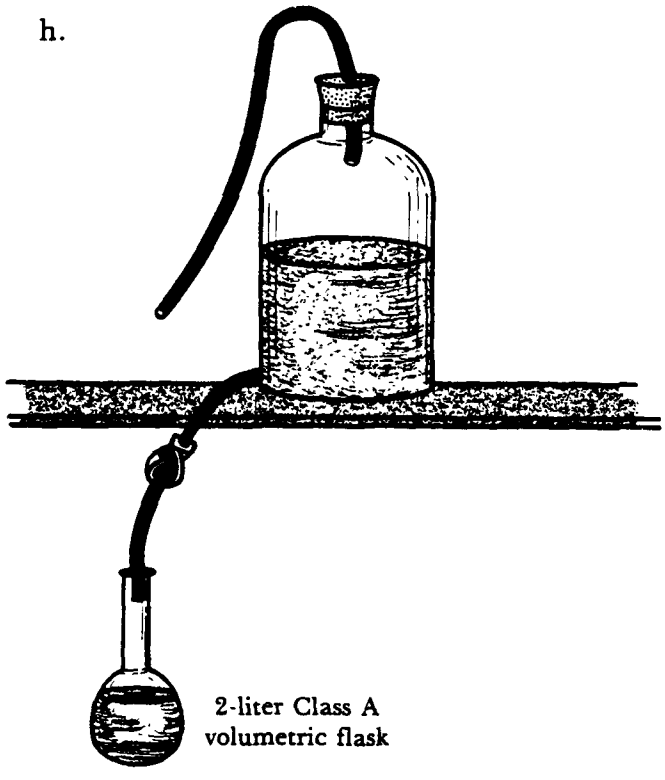
f.


Gas in
Gas out
Pressure taps

g.

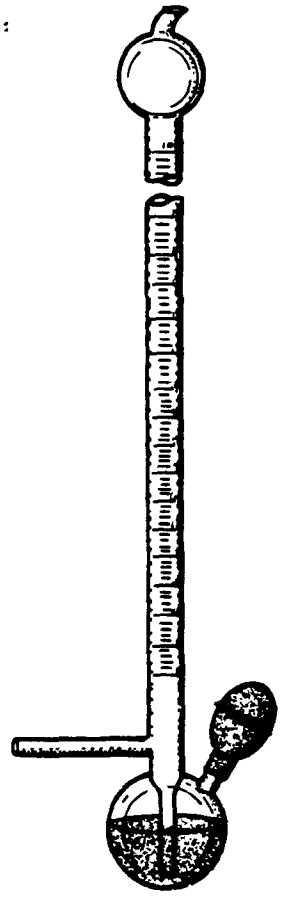

Tubing adapter
Pipe coupling
Stainless steel tubing

h.

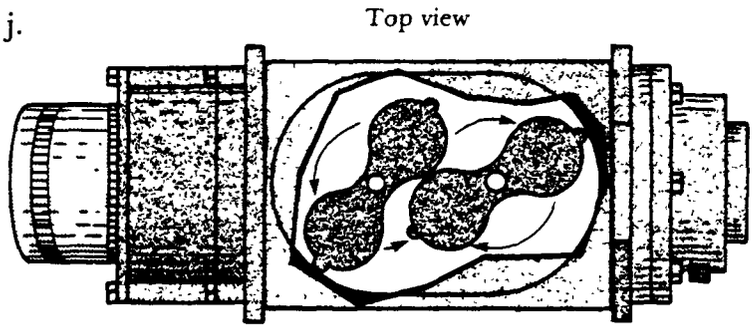


2-liter Class A
volumetric flask

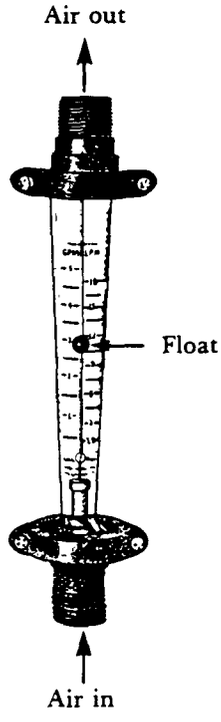
i.



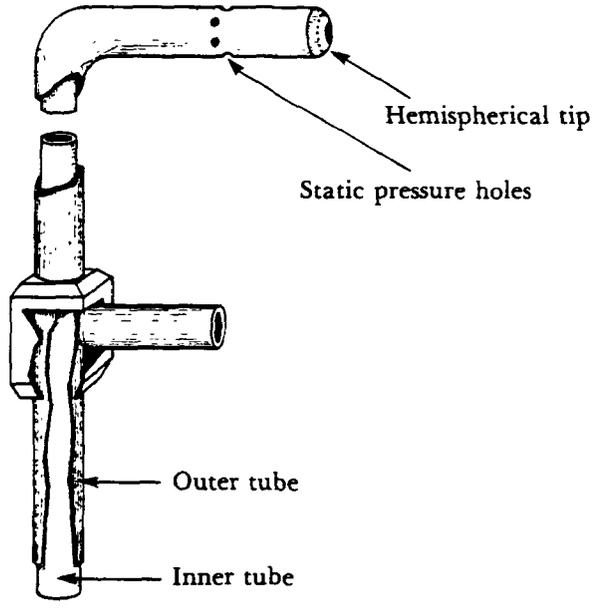
j.


Top view

k.


Air out
Float
Air in

l.


Hemispherical tip
Static pressure holes
Outer tube
Inner tube

For each of questions 45 through 57, match the air measuring device with its appropriate description.

45. mass flow meter
46. spirometer
47. displacement bottle technique
48. soap bubble meter
49. mercury-sealed piston
50. wet test meter
51. Roots meter
52. dry test meter
53. orifice meter
54. venturi meter
55. rotameter
56. standard pitot tube
57. S-type pitot tube

a. This device works on the principle that as a gas passes over a heated surface, heat is transferred from the surface to the gas. The amount of current required to keep the surface at a constant temperature is a measure of the velocity of the gas.

b. This device consists of two identical tubes mounted back to back. The sampling end of the tubes are oval with the openings parallel to each other. In use, one oval opening should point directly upstream, the other directly downstream.

c. This device consists of a vertically graduated glass tube, slightly tapered in bore, with the diameter decreasing from top to bottom, containing a float of the appropriate material and shape. The fluid to be measured passes upward through the conical tube, which is inserted in the flow circuit.

d. This device consists of a short cylindrical inlet, an entrance cone, a short cylindrical throat, and finally a diffuser cone. Two pressure taps, one in the cylindrical inlet and one in the throat, serve to measure the pressure drop.

e. This device can consist of a thin plate having one circular hole coaxial with the pipe into which it is inserted. Two pressure taps, one upstream and one downstream of the orifice, serve as a means of measuring the pressure drop, which can be correlated to the time rate of flow.

f. This device consists of two concentric tubes. The center tube measures the impact pressure while the static pressure is measured by the holes located on the side of the outer tube.

g. The interior of this device contains two or more movable partitions, or diaphragms, attached to the case by a flexible material so that each partition may have a reciprocating motion. The gas flow alternately inflates and deflates each bellows chamber, simultaneously actuating a set of slide valves that shunt the incoming flow at the end of each stroke. The inflation of the successive chambers also actuates, through a crank, a set of dials that register the volume of gas passed through the device.

h. This device consists of a series of inverted buckets or traps mounted radially around a shaft and partially immersed in water. The location of the entry and exit gas ports is such that the entering gas fills a bucket, displacing the water and causing the shaft to rotate due to the lifting action of the bucket full of air. The entrapped air is released at the upper portion of the rotation and the bucket again fills with water. In turning, the drum rotates index pointers that register the volume of gas passed through the meter.

i. This device consists of a cylinder of known volume, closed at one end, with the open end submerged in a circular tank of fluid. The cylinder can be opened or closed to the atmosphere by a valve. As the cylinder is lowered into the water, the water displaces the air and causes it to be discharged from the cylinder; the rate of discharge can be regulated.

j. This device consists basically of two oppositely rotating impellers of two-lobe or "figure 8" contour, operating within a rigid casing. The casing is arranged with inlet and outlet gas connections on opposite sides.

k. This device consists of a precision-bored, borosilicate glass cylinder with a close fitting polyvinyl chloride piston. The piston and cylinder wall are sealed with a ring of mercury that stays in place because of its high viscosity and the closenesss of the fit between the cylinder and piston.

l. This device consists of a bottle filled with a liquid and a tube through which air can enter the bottle. As the liquid in the bottle is drained or siphoned out, air is drawn in, to take the place of the volume of liquid lost. The volume of gas sampled is equal to the volume of liquid displaced. The volume of displaced liquid is measured with a Class A volumetric flask.

m. This device consists of a cylindrical glass tube with graduated markings. Either a vacuum at the top or slight positive pressure at the bottom of the tube moves a soap bubble up the tube. By timing this movement and noting the volume traversed by the bubble, over the measured time span, volumetric flow rate can be calculated.

For each of questions 58 through 70, match the air measuring device with its appropriate category.

58. mass flow meter
59. spirometer
60. displacement bottle technique
61. soap bubble meter
62. mercury-sealed piston
63. wet test meter
64. Roots meter
65. dry test meter
66. orifice meter
67. venturi meter
68. rotameter
69. standard pitot tube
70. S-type pitot tube

a. volume meter
b. variable pressure rate meter
c. variable area rate meter
d. velocity meter

For each of questions 71 through 83, match the air measuring device with its appropriate standard meter classification.

71. mass flow meter
72. spirometer
73. displacement bottle technique
74. soap bubble meter
75. mercury-sealed piston
76. wet test meter
77. Roots meter
78. dry test meter
79. orifice meter
80. venturi meter
81. rotameter
82. standard pitot tube
83. S-type pitot tube

a. primary
b. intermediate
c. secondary

84. Which of the following equations is used to correct air volumes measured by soap bubble meters and wet test meters to dry conditions?

a. $V_c = V_{meas}\left(\frac{P_b + P_w}{P_b}\right)$

b. $V_c = V_{meas}\left(\frac{P_b}{P_b + P_w}\right)$

c. $V_c = V_{meas}\left(\frac{P_b - P_w}{P_b}\right)$

d. $V_c = V_{meas}\left(\frac{P_b}{P_b - P_w}\right)$

Where: V_c = corrected volume
V_{meas} = measured volume
P_b = atmospheric pressure
P_w = vapor pressure of water at the room's temperature during measurement

85. True or False? The most accurate method of calibrating a soap bubble meter is to measure its dimensions.

86. Wet test meters can be used to measure flow rates up to ____(?)____ revolutions per minute.
a. 1
b. 3
c. 5
d. 10

87. True or False? Excessive particulate matter in the gas stream being measured can impede the operation of a Roots meter.

88. Which of the following is an(are) advantage(s) of a dry test meter over a wet test meter?
a. Measured air volumes do not have to be corrected to dry conditions when using a dry test meter.
b. Dry test meters are lighter and easier to use.
c. both a and b, above
d. none of the above

89. Which of the following equations is used to correct air volumes measured by volume meters to EPA's STP conditions?

a. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$

b. $V_2 = (V_1)\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$

c. $V_2 = (V_1)\left(\frac{P_1}{P_2}\right)\left(\frac{T_1}{T_2}\right)$

d. $V_2 = (V_1)\left(\frac{P_1}{T_1}\right)\left(\frac{P_2}{T_2}\right)$

Where: V_2 = corrected volume of air at EPA's STP conditions
V_1 = measured volume of air at P_1 and T_1
T_1 = measured temperature of gas, K
T_2 = 298 K
P_1 = measured pressure of gas, mm Hg
P_2 = 760 mm Hg

90. Which of the following is a(are) category(ies) of rate meters?
a. variable pressure (head) meters
b. variable area meters
c. both a and b, above
d. none of the above

91. True or False? Variable pressure meters are those in which a stream of fluid creates a significant pressure difference that can be measured and correlated with the time rate of flow.

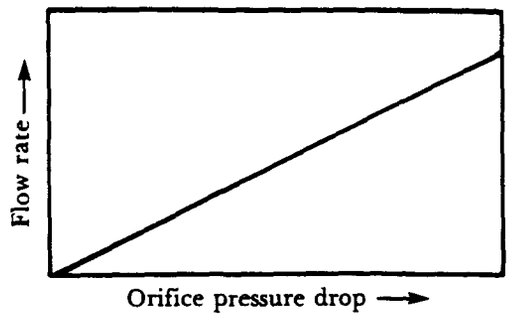
92. The pressure drop across a variable area meter ____(?)____ as the flow rate through the variable area meter changes.
a. increases
b. decreases
c. remains constant

93. The cross-sectional area of the annulus of a variable area meter ____(?)____ as the flow rate through the variable area meter increases.
a. increases
b. decreases
c. remains constant

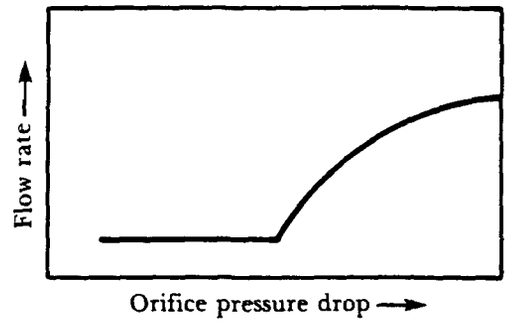
94. True or False? A critical orifice is an orifice meter having a pressure drop such that any further decrease in its downstream pressure or increase in its upstream pressure will not change the gas flow rate through it.

95. Which one of the following figures depicts a critical orifice calibration curve?

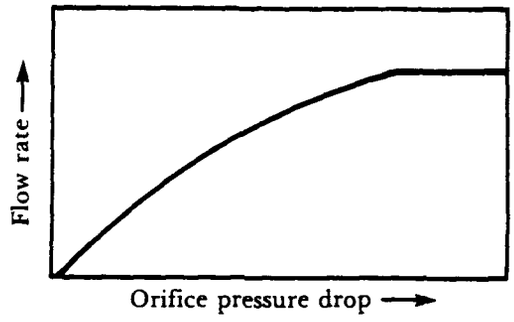
a.



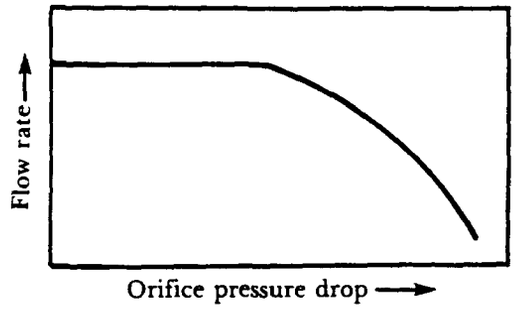
b.



c.



d.



96. True or False? Gas density affects flow rate measurements made by rotameters.

97. Which of the following equations is used to correct flow rates measured by rate meters to EPA's STP conditions?

a. $Q_2 = Q_1 \left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)$

b. $Q_2 = Q_1 \left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)$

c. $Q_2 = Q_1 \left[\left(\frac{P_2}{P_1}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

d. $Q_2 = Q_1 \left[\left(\frac{P_1}{P_2}\right)\left(\frac{T_2}{T_1}\right)\right]^{1/2}$

Where: Q_2 = corrected flow rate at EPA's STP conditions
Q_1 = measured flow rate at P_1 and T_1
T_1 = measured temperature of gas, K
T_2 = 298 K
P_1 = measured pressure of gas, mm Hg
P_2 = 760 mm Hg

98. True or False? Under typical sampling conditions, gas temperature and pressure affect flow rate measurements made by mass flow meters.

99. True or False? Thermal properties of gases affect flow rate measurements made by mass flow meters.

Section A-2

Review Exercise Answers

		Page(s) of *Atmospheric Sampling: Student Manual*
1.	True	3-1
2.	g	3-2, 3-3, 3-4
3.	c	3-2
4.	d	3-3
5.	c	3-3
6.	b	3-5
7.	a	3-6
8.	d	3-6
9.	c	3-7
10.	b	3-8
11.	a	3-8
12.	False	3-9
13.	a	3-10
14.	True	3-12
15.	d	3-13
16.	True	3-14, 3-15
17.	d	3-15, 3-16
18.	b	3-16
19.	True	3-16
20.	e	3-17
21.	c	3-17
22.	True	3-18
23.	d	3-18
24.	d	3-18
25.	a	3-18
26.	b	3-19
27.	c	3-19
28.	True	3-19
29.	d	3-19
30.	a	3-19
31.	b	3-19
32.	a	3-19
33.	a	3-20
34.	h	3-22, 3-30
35.	i	3-24
36.	c	3-26
37.	b	3-29
38.	j	3-32

	Page(s) of *Atmospheric Sampling: Student Manual*
39. d	3-34
40. e	3-36
41. f	3-38
42. k	3-39
43. l	3-43
44. g	3-44
45. a	3-45
46. i	3-20
47. l	3-22, 3-23
48. m	3-23, 3-24
49. k	3-25
50. h	3-28
51. j	3-31
52. g	3-35
53. e	3-36
54. d	3-38
55. c	3-39
56. f	3-42
57. b	3-44
58. d	3-40, 3-45
59. a	3-20
60. a	3-20, 3-22
61. a	3-20, 3-23
62. a	3-20, 3-25
63. a	3-20, 3-28
64. a	3-20, 3-31
65. a	3-20, 3-33
66. b	3-36
67. b	3-36, 3-38
68. c	3-38, 3-39
69. d	3-40, 3-42
70. d	3-40, 3-44
71. c	3-45
72. a	3-20
73. a	3-22
74. a	3-23
75. a	3-23, 3-25
76. b	3-28
77. b	3-31
78. b	3-33
79. c	3-36
80. c	3-38
81. c	3-39
82. a	3-42

	Page(s) of *Atmospheric Sampling: Student Manual*
83. c	3-44
84. c	3-25, 3-30
85. False	3-25
86. b	3-31
87. True	3-31
88. c	3-35
89. a	3-21, 3-24, 3-33
90. c	3-36, 3-38
91. True	3-36
92. c	3-38
93. a	3-39
94. True	3-37
95. c	3-37
96. True	3-40
97. d	3-37, 3-40
98. False	3-45
99. True	3-45

Section A-3

Inertial Sampling for Particulate Matter

Reading Assignment

Pages 4-1 through 4-30 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Principles of inertial sampling devices
- Types of inertial sampling devices
- Collection efficiency of impactors
- Sources of error in inertial sampling
- Applications of inertial sampling devices

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with the inertial sampling of particulate matter.

Learning Objectives

At the end of this section, you should be able to:

1. recognize the distribution and respirability of particles in ambient air.
2. identify at least six inertial collection devices used for ambient particulate matter sampling.
3. identify optimum conditions for sampling ambient particulate matter using inertial collection devices.
4. define inertial and centrifugal sampling of particulate matter.
5. recognize two applications of inertial sampling devices and identify at least five sources of error in the inertial sampling of particulate matter.
6. name the two major inertial collection mechanisms for particulate matter.
7. define the particulate matter collection efficiency of an impactor.

Reading Guidance

- Refer often to the equations and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section A-3. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any), take Quiz 1. Follow the directions listed in the Course Introduction section of this guidebook.
- After completing Quiz 1, proceed to Section A-4 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section A-3, please answer the following questions. These will help you determine whether or not you are mastering the material.

1. True or False? Ambient air particles having diameters of about 0.4 μm are mostly manmade, while a significant portion of particles with diameters of about 10 μm are caused by natural processes.
2. Particles having diameters of approximately ____(?)____ μm or less are generally thought to be inhaled into the lower respiratory system.
   a. 10
   b. 50
   c. 75
   d. 100

For each of questions 3 through 10, match the particulate sampling method or device with its appropriate description.

3. virtual impactor
4. cyclone sampler
5. cascade impactor
6. single stage impactor
7. inertial sampling
8. impinger
9. air centrifuge
10. centrifugal sampling

a. This method is based on the principle that the momentum of a particle in a moving air stream will cause the particle to be deflected less than the air in the vicinity of the particle when the air stream undergoes a sudden change in direction.

b. An impaction sampler which contains one jet and one collection surface.

c. This impaction device consists of several impaction stages arranged in a series.

d. The jet and striking surface of this device are immersed in a collecting fluid.

e. In this method, particles are removed from an air stream by the force created by moving an aerosol rapidly through a circular path.

f. This device, which contains no moving parts, is designed so that air drawn through it will move in either a circular or a helical path of decreasing radius in order to increase the collection efficiency of small particles. The sample air stream surges through the device and the particles of the air stream are separated at the inside surface of the device's wall by centrifugal force.

(g. and h. are listed on the following page)

g. In this device, the sample air passes between two concentric cones. The inner cone is rotated by a motor and draws air in at the narrow upper end of the cones and exhausts the air at the large end of the cones. Particles of the air stream are collected on the inside surface of the outer cone.

h. In this device, larger particles are impacted into a slowly pumped void and are collected on a filter downstream of the void.

11. True or False? Impaction and impingement are major general inertial collection mechanisms for particulate matter.

12. True or False? Impaction devices collect and retain particles of an air stream on a surface.

13. True or False? Overlapping of particle size samples occurs when impactors are used to collect particulate matter.

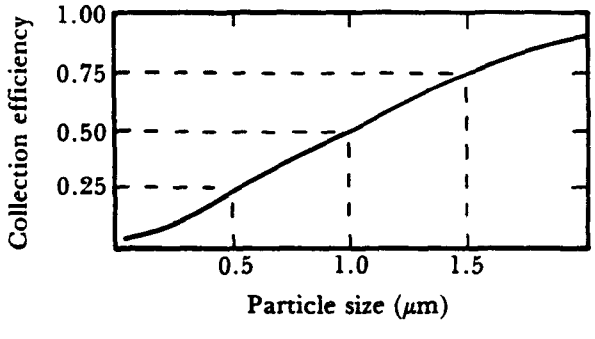
14. True or False? The collection efficiency of a cyclone sampler is affected by the flow rate of sample air through the sampler.

15. True or False? The collection efficiency of an impactor can be defined as the fraction of the particles in an incident aerosol stream that is retained on the collection surface of the impactor.

16. True or False? The particle size collection range of an impactor or an impactor stage should be narrow enough that a functional size separation can be made.

17. The D_{50} for the impaction device whose particle size collection efficiency is depicted below is ____(?)____ μm.

    a. 0.5
    b. 1.0
    c. 1.5



18. Which of the following particle characteristics affect(s) the collection efficiency of an inertial sampling device?
    a. particle size
    b. particle density
    c. both a and b, above

19. True or False? Impaction devices are inefficient collectors of high density particles.

20. Which of the following characteristics of an inertial sampling device affect(s) its collection efficiency?
    a. jet size
    b. jet shape
    c. distance between jet and collection surface
    d. collection surface
    e. all of the above

21. As the jet size of an impactor ____(?)____, the impaction velocity ____(?)____.
    a. increases, increases
    b. decreases, decreases
    c. decreases, increases

22. True or False? The collection efficiency of an impaction device is not affected by the flow rate of sample air through the device.

23. True or False? Changing the shape of an impaction device's jets from round to rectangular greatly affects the device's collection efficiency.

24. As the distance between an impactor's jet and its collection surface ____(?)____, the angle of deflection of an aerosol stream passing through the impactor ____(?)____.
    a. decreases, increases
    b. increases, increases
    c. decreases, decreases

25. The angle of deflection of an aerosol stream passing through an impaction device must ____(?)____ in order for the device to remove small particles of the aerosol stream.
    a. be small
    b. be large
    c. remain constant

26. True or False? Particle retention is greatest for flat impaction surfaces.

27. Inertial sampling devices have been used for which of the following?
    a. particle size distribution studies
    b. gross sampling
    c. both a and b, above
    d. none of the above

28. True or False? For microscopic analysis, it is desirable to collect a particulate matter sample on the viewing surface that is intended to be used for the analysis.

29. True or False? The particle diameter corresponding to the 50% fraction of a cumulative weight distribution curve for a particulate sample is the sample's mass median diameter.

30. Which of the following is ***not*** a potential source of error in inertial sampling?
    a. particle shattering
    b. particle bounce
    c. particle re-entrainment
    d. wall losses
    e. collection device calibration
    f. sample analysis error
    g. none of the above

Section A-3

Review Exercise Answers

	Page(s) of *Atmospheric Sampling: Student Manual*
1. True	4-1, 4-2
2. a	4-1, 4-2
3. h	4-17
4. f	4-15
5. c	4-6
6. b	4-5
7. a	4-3
8. d	4-14
9. g	4-16
10. e	4-15
11. True	4-4
12. True	4-5
13. True	4-9
14. True	4-15
15. True	4-24
16. True	4-24
17. b	4-24, 4-25
18. c	4-25
19. False	4-25
20. e	4-26, 4-27
21. c	4-26
22. False	4-26
23. False	4-26
24. a	4-26
25. b	4-26
26. True	4-27
27. c	4-29, 4-30
28. True	4-30
29. True	4-30
30. g	4-27, 4-28, 4-29

Section A-4

Introduction to Pertinent Statistical Techniques for Air Monitoring

Reading Assignment

Pages 10-1 through 10-17 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Data plots
- Measures of central tendency
- Measures of dispersion
- Distribution curves

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with statistical techniques pertaining to air monitoring.

Learning Objectives

At the end of this section, you should be able to:

1. identify and define the two statistical variables associated with atmospheric sampling data.
2. construct a data frequency table, frequency polygon, histogram, and cumulative frequency distribution curve from a given set of air quality data.
3. describe a data distribution.
4. use probability graph paper in analyzing air quality data.
5. define and use linear regression.
6. calculate and recognize the usefulness of the arithmetic mean, median, geometric mean, and range.
7. recognize normal and log normal distribution curves.
8. identify equations used to calculate and recognize the usefulness of the standard deviation and the standard geometric deviation.

Reading Guidance

- Refer often to the equations, example calculations, and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section A-4. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any), proceed to Section B-1 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section A-4, please answer the following questions. These will help you determine whether or not you are mastering the material.

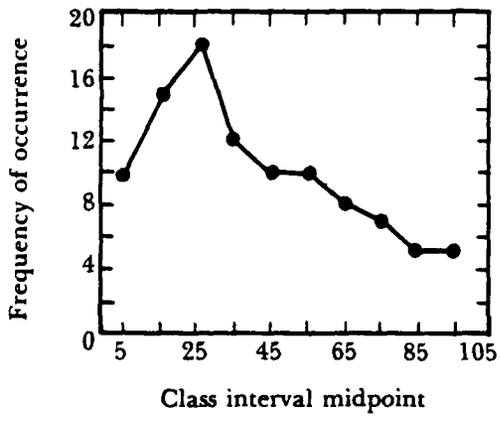
1. Which of the following is a(are) general variable(s)?
   a. continuous variable
   b. discrete variable
   c. both a and b, above
2. True or False? A continuous variable is one that can assume any value within some interval of values.
3. True or False? Discrete variables are those whose possible values are intergers.
4. As a rule of thumb, a data frequency table should consist of ____(?)____ data class intervals.
   a. 1 to 3
   b. 3 to 5
   c. 8 to 15
   d. 20 to 30

5. Which one of the following frequency polygons represents the data given in the frequency table below?

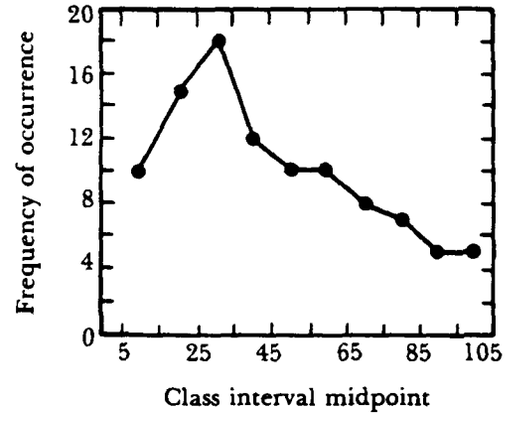
Frequency table

Class interval	Frequency of occurrence
0-10	10
10-20	15
20-30	18
30-40	12
40-50	10
50-60	10
60-70	8
70-80	7
80-90	5
90-100	5

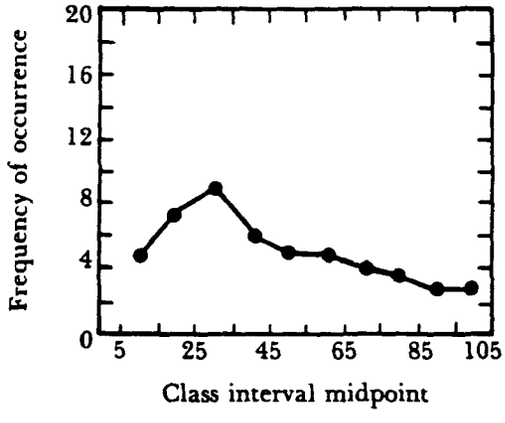
a.



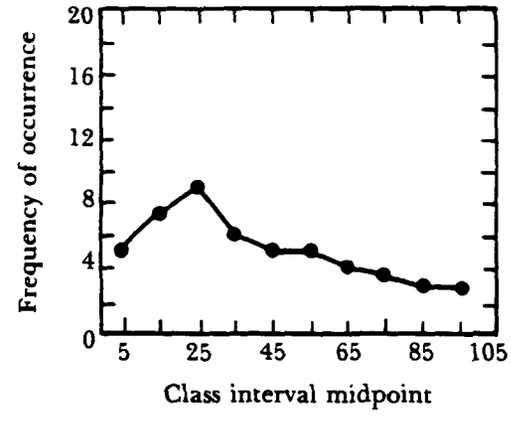
b.



c.



d.

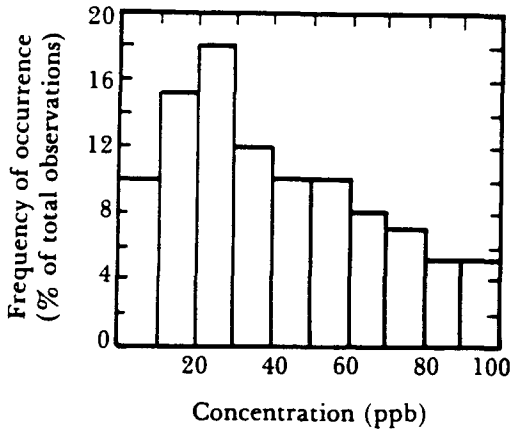


6. Which one of the following histograms represents the data given in the frequency table below?

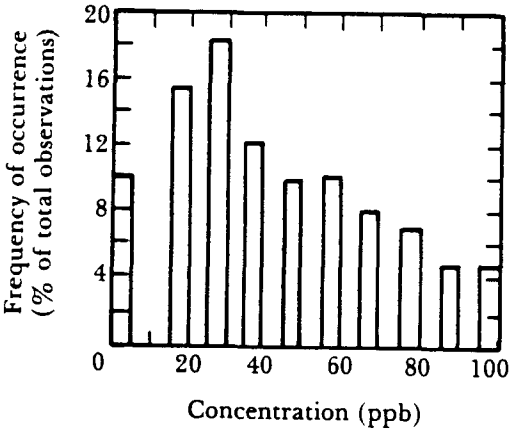
Frequency table

Concentration class interval (ppb)	Frequency of occurrence
0-10	10
10-20	15
20-30	18
30-40	12
40-50	10
50-60	10
60-70	8
70-80	7
80-90	5
90-100	5

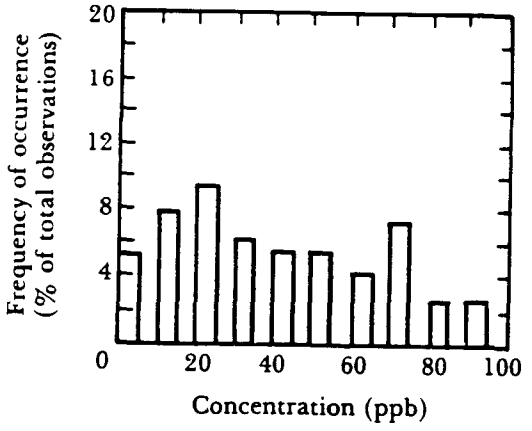
a.



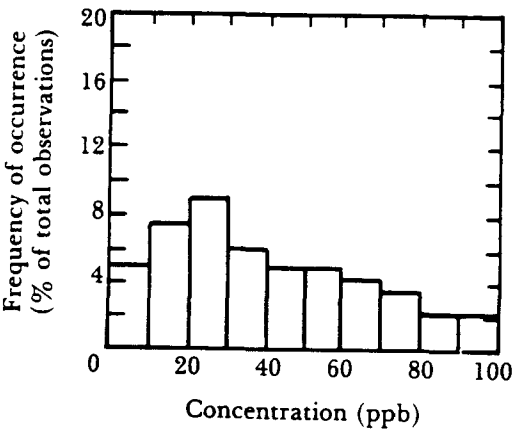
b.



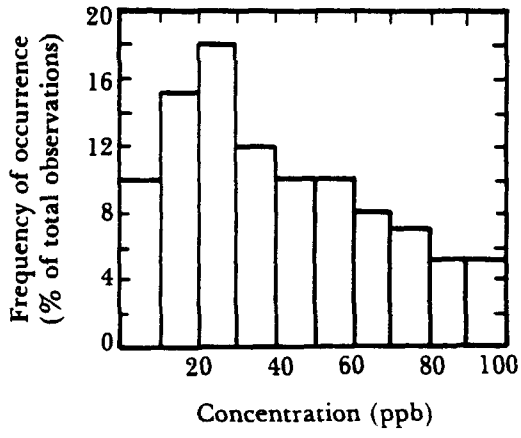
c.



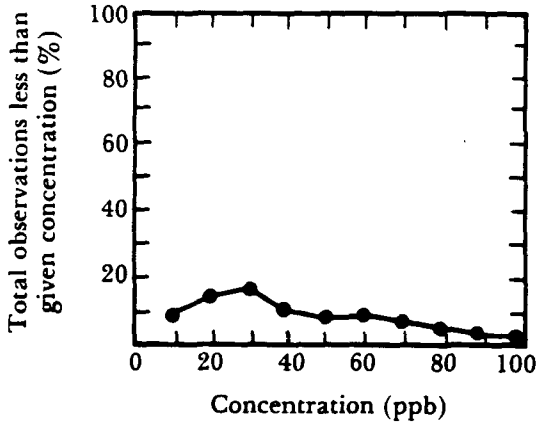
d.



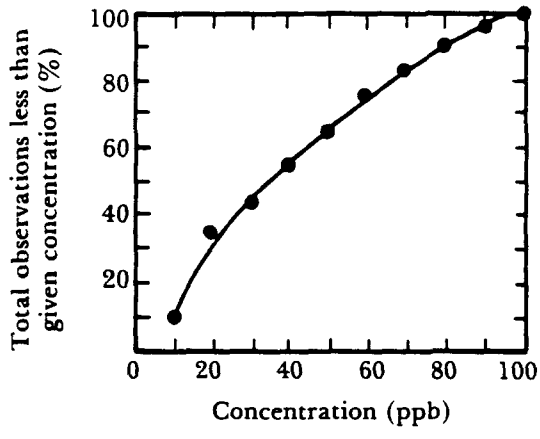
7. Which one of the following cumulative frequency distribution curves represents the data given in the histogram below?



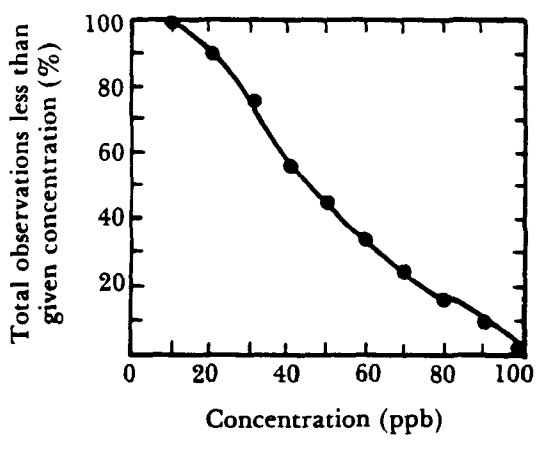
a.



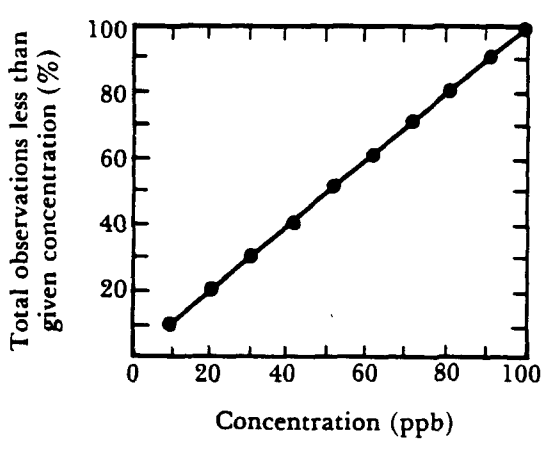
b.



c.

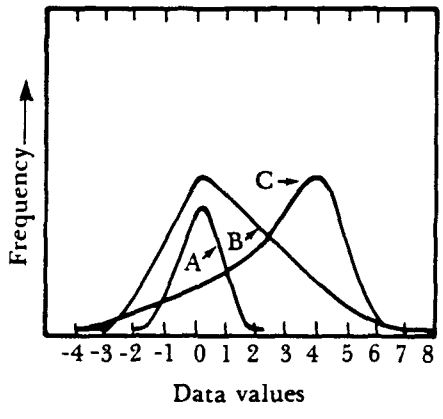


d.



8. Which of the following is a(are) basic characteristic(s) of data distributions?
   a. central location
   b. dispersion
   c. skewness
   d. all of the above

9. In the figure below, curve ____(?)____ is skewed to the right, curve ____(?)____ is skewed to the left, and curve ____(?)____ is not skewed.
   a. A, B, C
   b. B, C, A
   c. C, B, A
   d. A, C, B



10. True or False? When the arithmetic and logarithmic scales of a data cumulative frequency distribution curve are plotted on probability graph paper, the scale which causes the frequency distribution curve to be more nearly a straight line better approximates a normal data distribution.

11. The ____(?)____ percentile of a data set's cumulative frequency distribution curve plotted on probability graph paper is an estimate of the mean of the data set.
   a. 25th
   b. 50th
   c. 75th
   d. 100th

12. The distance between the ____(?)____ percentile and the ____(?)____ percentile of a data set's cumulative frequency distribution curve plotted on probability graph paper is an estimate of the standard deviation of the data set.
   a. 75th, 50th
   b. 50th, 25th
   c. 50th, 16th
   d. 35th, 14th

13. True or False? Linear regression is the mathematical process of minimizing the vertical distance between all the points of a data set and a straight line represented by the data set.

14. Which one of the following equations gives the best straight line using the data set below?
    a. $y = 1.13x - 2.0$
    b. $y = 0.87x + 2.8$
    c. $y = 1.72x + 3.0$
    d. $y = 1.67x + 3.3$

x	y
4	10
10	20
16	30

For each of questions 15 through 17, match the parameter with its value for the following data set: 2, 4, 8, and 12.

15. mean — a. 10
16. median — b. 6.5
17. range — c. 6

18. Extreme values of a data set have ____(?)____ influence on the data set's mean than(as) on the data set's median.
    a. greater
    b. lesser
    c. the same

19. The geometric mean of a data set consisting of five data values is calculated by taking the ____(?)____ root of the ____(?)____ of the five data values.
    a. square, product
    b. square, sum
    c. 5th, sum
    d. 5th, product

20. The geometric mean of a log normally distributed data set gives ____(?)____ measure of the data set's central location as(than does) the data set's arithmetic mean.
    a. the same
    b. a more accurate
    c. a less accurate

21. True or False? The standard deviation is the most commonly used measure of dispersion for a normally distributed data set.

22. Which one of the following equations is the most accurate and easiest to use for calculating standard deviation?

a. $\sqrt{\frac{\Sigma(X_i - \overline{X})^2}{n-1}}$

b. $\sqrt{\frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}{n-1}}$

c. $\text{antilog}\left[\frac{\Sigma(\log X - \overline{\log X})^2}{n-1}\right]^{1/2}$

d. $\text{antilog}\left[\frac{\Sigma(\log X)^2 - \frac{(\Sigma \log X)^2}{n}}{n-1}\right]^{1/2}$

Where: X_i = a data value
$\overline{X}$ = the mean of the data sample
n = the number of observations

23. True or False? The standard geometric deviation is an appropriate measure of the dispersion of a log normally distributed data set.

24. Which one of the following equations is the most accurate and easiest to use for calculating standard geometric deviation?

a. $\sqrt{\frac{\Sigma(X_i - \overline{X})^2}{n-1}}$

b. $\sqrt{\frac{n\Sigma X_i^2 - (\Sigma X_i)^2}{n(n-1)}}$

c. $\text{antilog}\left[\frac{\Sigma(\log X - \overline{\log X})^2}{n-1}\right]^{1/2}$

d. $\text{antilog}\left[\frac{\Sigma(\log X)^2 - \frac{(\Sigma \log X)^2}{n}}{n-1}\right]^{1/2}$

Where: X_i = a data value
$\overline{X}$ = the mean of the data sample
n = the number of observations

25. Which of the following is a(are) characteristic(s) of a normal (Gaussian) distribution curve?
    a. it has symmetry
    b. its mean and median are both found in the center of the curve
    c. it has an infinite range
    d. both a and b, above
    e. all of the above

For each of questions 26 through 28, match the normal (Gaussian) distribution curve parameter with its corresponding percent area under the normal curve.

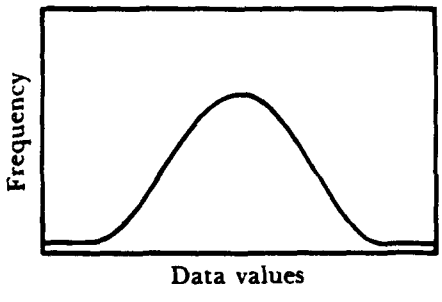
26. ± 1 standard deviation from the mean
27. ± 2 standard deviations from the mean
28. ± 3 standard deviations from the mean

a. 50.4%
b. 68.2%
c. 95.4%
d. 99.7%

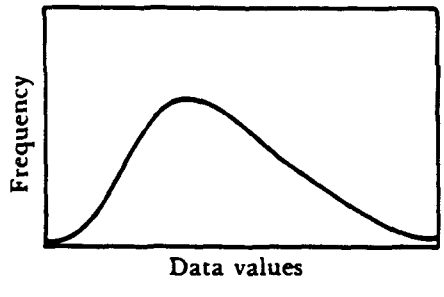
For each of questions 29 and 30, match the data distribution curve with its appropriate figure.

29. normal (Gaussian) distribution curve
30. log normal distribution curve

a.



b.



31. True or False? A data value of a data set that is more than ± 3 standard deviations away from the mean of the data set is probably an erroneous value.

Section A-4
Review Exercise Answers

	Page(s) of *Atmospheric Sampling: Student Manual*
1. c	10-1
2. True	10-1
3. True	10-1
4. c	10-3
5. a	10-2, 10-3
6. a	10-3, 10-4
7. b	10-4, 10-5
8. d	10-5
9. b	10-5, 10-6
10. True	10-7, 10-8
11. b	10-8
12. c	10-8
13. True	10-8
14. d	10-9, 10-10
15. b	10-10
16. c	10-11
17. a	10-13
18. a	10-11
19. d	10-11, 10-12
20. b	10-12
21. True	10-13
22. b	10-13
23. True	10-14
24. d	10-14
25. e	10-14, 10-15
26. b	10-15, 10-16
27. c	10-15, 10-16
28. d	10-15, 10-16
29. a	10-14
30. b	10-17
31. True	10-16

Part B

Section B-1

High Volume Sampling of Particulate Matter and Evaluation of Filter Media

Reading Assignment

Pages 4-31 through 4-84 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- High volume air sampling
- Evaluation of filter media

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with the high volume sampling of particulate matter and filters used for particulate matter sampling.

Learning Objectives

At the end of this section, you should be able to:

1. recognize at least three major components of a high volume sampler.
2. identify and give the locations of at least five components of a calibration set-up for calibrating a high volume sampler orifice-type flow rate transfer standard.
3. recognize that a flow rate transfer standard is needed to calibrate a high volume sampler's flow rate measuring device.
4. compare a calibration curve for a high volume sampler flow rate transfer standard to a high volume sampler flow rate measuring device calibration curve.
5. identify and describe how to minimize potential sources of error in high volume sampling.
6. recognize the use of Reference Flow (ReF) devices for auditing flow rate calibrations of high volume samplers.
7. identify at least four components of a high volume sampler that need periodic cleaning or replacement.
8. recognize at least four reasons for using a shelter when sampling suspended particulate matter using a high volume sampler.

9. name at least two devices that can be used to modify a high volume sampler for sampling inhalable particulate matter.
10. identify three objectives of high volume sampling.
11. calculate suspended particulate matter concentration from high volume sampling and analysis data.
12. identify three advantages and two disadvantages of using filters as the collection medium for particulate matter sampling.
13. name at least four filtration mechanisms and describe how they are affected by filter and sampling conditions.
14. define three terms used to express filter collection efficiency.
15. recognize advantages and disadvantages of cellulose, glass fiber, and membrane filters.

Reading Guidance

- Refer often to the figures, equations, and example calculations of the high volume air sampling portion of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section B-1. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any) proceed to Section B-2 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section B-1, please answer the following questions. These will help you determine whether or not you are mastering the material.

1. Which of the following is a(are) major component(s) of a high volume sampler?
   a. modified vacuum cleaner motor
   b. stainless steel filter holder
   c. photodetector
   d. both a and b, above
   e. both a and c, above

2. Which of the following is a(are) reason(s) for the use of a shelter when sampling suspended particulate matter using a high volume sampler?
   a. Shelter protects filter from direct impact of particulate matter.
   b. Shelter uniformly distributes particulate matter over the filter surface.
   c. Shelter prevents birds from damaging filter.
   d. both b and c, above
   e. both a and b, above

3. True or False? When using a high volume sampler, the sampling flow rate affects the size of particles collected.

4. Which of the following is ***not*** a reason for the use of glass fiber filters in routine high volume sampling?
   a. They have collection efficiencies of at least 99%.
   b. They have low resistance to air flow.
   c. They have low affinity for moisture.
   d. They are suitable for the analysis of many organic and inorganic particulate pollutants.
   e. They cost less than other filters.

5. In order to eliminate weigh errors due to small amounts of moisture, both unexposed and exposed glass fiber filters should be equilibrated at ____(?)____°C and less than ____(?)____% relative humidity for 24 hours before weighing.
   a. 0-5, 50
   b. 15-35, 25
   c. 15-30, 50
   d. 15-35, 75

6. True or False? Blank concentrations of pollutants in clean glass fiber filters should be taken into account when analyzing exposed filters for pollutants.

7. Which of the following is a(are) disadvantage(s) of using cellulose filters for high volume sampling?
   a. By rapidly clogging, they cause sampling flow rates to dramatically decrease.
   b. They have low ash and metal content.
   c. They enhance the artifact formation of sulfates and nitrates.
   d. both a and c, above
   e. both b and c, above

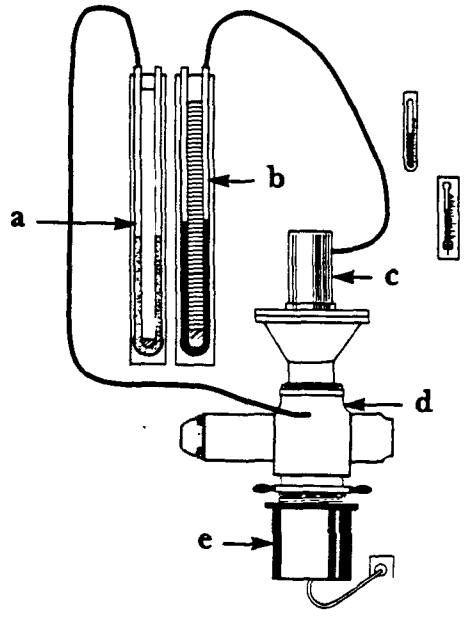
8. True or False? Folding or creasing a high volume filter before sampling may cause erroneous flow patterns through the filter during sampling.

9. True or False? If an exposed high volume filter's border is fuzzy or nonexistent, sample air may have leaked under the filter's gasket during sampling.

10. True or False? After sampling, an exposed high volume filter should be folded in half lengthwise so that collected particulate matter on one half of the filter does not touch collected particulate matter on the other half of the filter, for transport to the laboratory for analysis.

11. Which of the following is a(are) device(s) used to measure sampling flow rates of high volume samplers?
   a. orifice/pressure indicators
   b. mass flowmeters
   c. Roots meters
   d. both a and b, above
   e. all of the above

12. In the calibration set-up for a high volume sampler flow rate transfer standard depicted below a, b, c, d, and e are the ____(?)____ respectively.
   a. water manometer, mercury manometer, flow rate transfer standard, Roots meter, and high volume motor
   b. mercury manometer, water manometer, flow rate transfer standard, Roots meter, and high volume motor
   c. mercury manometer, water manometer, high volume motor, Roots meter, and flow rate transfer standard
   d. water manometer, mercury manometer, flow rate transfer standard, high volume motor, and Roots meter



13. The U.S. EPA high volume sampling procedure requires that high volume samplers be operated at sampling flow rates of ____(?)____ to ____(?)____ m^3/min.
    a. 1.0, 2.0
    b. 1.1, 1.7
    c. 1.0, 1.5

14. A calibration curve for a high volume sampler flow rate transfer standard is constructed by plotting ____(?)____ versus ____(?)____.
    a. standard flow rate, $\sqrt{I(P_2/P_{std})(298/T_2)}$
    b. flow rate transfer standard pressure drop, Roots meter pressure drop
    c. standard flow rate, $\sqrt{\Delta H(P_1/P_{std})(298/T_1)}$
    d. standard flow rate, indicated flow rate

15. Which of the following items is(are) needed to calibrate a high volume sampler's flow rate measuring device?
    a. rotameter
    b. elutriator
    c. mass flow controller
    d. both a and b, above
    e. flow rate transfer standard
    f. all of the above

16. Which of the following equations is used to correct air volumes measured by positive displacement standard volume meters to standard air volumes for the calibration of high volume sampler flow rate transfer standards?

    a. $V_{std} = V_m \left(\frac{P_1}{P_{std} - \Delta P}\right) \frac{T_{std}}{T_1}$

    b. $V_{std} = V_m \left(\frac{P_1 - \Delta P}{P_{std} - \Delta P}\right) \frac{T_{std}}{T_1}$

    c. $V_{std} = V_m \left(\frac{P_1 - \Delta P}{P_{std}}\right) \frac{T_1}{T_{std}}$

    d. $V_{std} = V_m \left(\frac{P_1 - \Delta P}{P_{std}}\right) \frac{T_{std}}{T_1}$

    Where: V_{std} = standard volume, std m^3
    V_m = actual volume measured by the standard volume meter
    P_1 = barometric pressure during calibration, mm Hg or kPa
    ΔP = pressure drop at inlet to volume meter, mm Hg or kPa
    P_{std} = 760 mm Hg or 101 kPa
    T_{std} = 298 K
    T_1 = ambient temperature during calibration, K.

17. A calibration curve for a high volume sampler flow rate measuring device is constructed by plotting ____(?)____ versus ____(?)____.
    a. standard flow rates, appropriately expressed flow rates indicated by the high volume sampler's flow rate measuring device
    b. flow rate transfer standard pressure drops, appropriately expressed flow rates indicated by the high volume sampler's flow rate measuring device
    c. standard flow rates, flow rate transfer standard pressure drops

18. Which of the following is a(are) potential source(s) of error in high volume sampling?
    a. nonuniform flow rate changes during sampling
    b. wind directional sensitivity caused by the gabled roof of the high volume sampler's shelter
    c. artifact particulate matter formation on alkaline high volume filters
    d. all of the above

19. Which of the following devices can minimize errors caused by nonuniform changes in high volume sampler flow rates during sampling?
    a. pressure transducer with continuous recorder for flow rate
    b. constant flow rate controllers
    c. both a and b, above
    d. none of the above

20. True or False? A Reference Flow (ReF) device can be used to audit the flow rate calibrations of high volume samplers.

21. True or False? Mass flow controllers maintain a constant high volume sampler flow rate by adjusting the speed of the high volume sampler's motor during sampling.

22. Which of the following devices can be used to modify a high volume sampler for sampling inhalable particulate matter?
    a. pressure transducers
    b. cyclone separators
    c. size selective inlets
    d. both b and c, above
    e. both a and b, above

23. True or False? Slightly increasing the line voltage to a high volume sampler's motor will increase motor brush life.

24. Which of the following components of a high volume sampler does ***not*** need periodic cleaning or replacement?
    a. flow rate measuring device
    b. tubing used in flow rate indication
    c. faceplate gasket
    d. motor gaskets
    e. none of the above

25. Which of the following is a(are) possible objective(s) of ambient high volume sampling?
    a. determination of the nature and magnitude of particulate pollutants in a given area
    b. prediction of particulate pollutant trends
    c. determination of particulate matter emission rates from stacks
    d. both a and b, above
    e. both b and c, above

26 True or False? High volume samplers provide continuous "real-time" particulate concentration data.

27. Under the conditions described below, the suspended particulate concentration obtained using a high volume sampler is _____(?)_____ $\mu g/std\ m^3$.
    a. 107
    b. 94
    c. 100
    d. 6

    Given: Weight of filter after sampling: 3.216 g
    Weight of filter before sampling: 3.000 g
    Initial sampling flow rate: 1.60 std m^3/min
    Final sampling flow rate: 1.40 std m^3/min
    Sampling period: midnight 7-11-81 to midnight 7-12-81

28. Which of the following is an(are) advantage(s) of using filters for particulate sampling?
    a. Large sampling flow rates can be used.
    b. The particulate sample is usually readily available for direct observation after sampling.
    c. Filters alone can adequately separate particulate matter into different size ranges.
    d. both a and b, above
    e. both b and c, above

29. Which of the following is a(are) disadvantage(s) of using filters for particulate sampling?
    a. Filters of the same type often vary in their physical and chemical properties.
    b. Filters alone cannot adequately separate particulate matter into different size ranges.
    c. both a and b, above
    d. none of the above

30. Which of the following contributes to the collection of particulate matter by filters?
    a. diffusion
    b. direct interception
    c. inertial collection
    d. both a and b, above
    e. all of the above

31. Particle diffusion rate ____(?)____ as the linear air flow velocity through a filter increases.
    a. remains the same
    b. increases
    c. decreases

32. Particle diffusion rate ____(?)____ as particle radius increases.
    a. remains the same
    b. increases
    c. decreases

33. Particle diffusion rate ____(?)____ as filter interfiber distance increases.
    a. remains the same
    b. increases
    c. decreases

34. True or False? Filter collection of particles by direct interception is analogous to mechanical straining.

35. Particle direct interception rate ____(?)____ as particle size increases.
    a. remains the same
    b. increases
    c. decreases

36. Particle direct interception rate ____(?)____ as filter interfiber distance increases.
    a. remains the same
    b. increases
    c. decreases

37. Particle direct interception rate ____(?)____ as filter fiber diameter increases.
    a. remains the same
    b. increases
    c. decreases

38. Within an optimum range of velocities, particle inertial collection rate ____(?)____ as the air flow velocity through a filter increases.
    a. remains the same
    b. increases
    c. decreases

39. Particle inertial collection rate ____(?)____ as particle density increases.
    a. remains the same
    b. increases
    c. decreases

40. Particle inertial collection rate ____(?)____ as particle size increases.
    a. remains the same
    b. increases
    c. decreases

41. Particle inertial collection rate ____(?)____ as filter fiber diameter increases.
    a. remains the same
    b. increases
    c. decreases

42. Particles having electrical charges which are ____(?)____ the electrical charge of a filter fiber are attracted to the filter.
    a. the same as
    b. opposite to
    c. neutral to

43. True or False? Electrical forces probably contribute to the collection of particles which are smaller than filter pore size.

44. Particle re-entrainment ____(?)____ as the filter face velocity increases.
    a. remains the same
    b. increases
    c. decreases

For each of questions 45 through 47, match the term with its appropriate definition.

45. percent penetration
46. percent collection
47. mass collection efficiency

a. percentage of the mass of particles that is collected by a filter
b. percentage of particles of a specified size that pass through a filter at a specified linear air flow velocity
c. percentage of particles of a specified size that is collected by a filter at a specified linear air flow velocity

48. Which of the following measures of filter collection efficiency would usually give misleading collection efficiency information.
    a. percent penetration
    b. percent collection
    c. mass collection efficiency
    d. all of the above

49. Which of the following is an(are) effect(s) of previously collected particulate matter on the filter collection of particles during sampling?
    a. increases filter collection eficiency
    b. possibly interferes with the sampling process by decreasing the flow rate of sample air through the filter
    c. both a and b, above
    d. none of the above

50. Which of the following is a(are) general category(ies) of filters?
    a. cellulose fiber
    b. glass fiber
    c. membrane
    d. both b and c, above
    e. all of the above

For each of questions 51 through 53, match the general category of filters with its appropriate list of advantages.

51. cellulose fiber
52. glass fiber
53. membrane

a. can withstand high temperatures, have high collection efficiency, nonhygroscopic, and can withstand corrosive atmospheres
b. have low ash and metal content
c. enhance the microscopic analysis of particulate matter, have low ash content, and are generally soluble in many organic solvents

For each of questions 54 through 56, match the general category of filters with its appropriate list of disadvantages.

54. cellulose fiber
55. glass fiber
56. membrane

a. have high affinity for moisture, irreversibly absorb water, and enhance the artifact formation of sulfate and nitrate
b. are fragile, difficult to ash, and absorb acid gases
c. are very brittle and cause appreciable pressure drops during sampling

57. True or False? The absorption of acid gases by glass fiber filters can be minimized by using glass fiber filters which have a neutral pH.

Section B-1
Review Exercise Answers

	Page(s) of *Atmospheric Sampling: Student Manual*
1. d	4-31
2. e	4-32
3. True	4-32
4. e	4-34, 4-35
5. c	4-34
6. True	4-35
7. d	4-35, 4-36
8. True	4-37
9. True	4-38
10. False	4-38
11. d	4-39
12. b	4-41
13. b	4-47
14. c	4-43
15. e	4-44
16. d	4-43
17. a	4-46
18. d	4-52, 4-53, 4-55
19. c	4-52, 4-53
20. True	4-55
21. True	4-52
22. d	4-58
23. False	4-56, 4-57
24. e	4-56, 4-57
25. d	4-58, 4-60
26. False	4-61
27. c	4-49, 4-61
28. d	4-63
29. c	4-63, 4-64
30. e	4-64, 4-65
31. c	4-66
32. c	4-66
33. b	4-66
34. True	4-64
35. b	4-64
36. c	4-67
37. c	4-67
38. b	4-67

	Page(s) of *Atmospheric Sampling: Student Manual*
39. b	4-68
40. b	4-68
41. c	4-68
42. b	4-65
43. True	4-65
44. b	4-65
45. b	4-65
46. c	4-65
47. a	4-66
48. c	4-66
49. c	4-68
50. e	4-69
51. b	4-69, 4-70
52. a	4-70
53. c	4-80
54. a	4-69
55. b	4-70
56. c	4-72, 4-73
57. True	4-70

Section B-2

Manual Sampling of Gaseous Pollutants

Reading Assignment

Pages 5-1 through 5-39 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Absorption of gaseous pollutants
- Adsorption of gaseous pollutants
- Grab sampling
- Freezeout sampling

Learning Goal and Objectives

Learning Goal

The purpose of this lesson is to familiarize you with manual sampling techniques for the sampling of gaseous pollutants.

Learning Objectives

At the end of this section, you should be able to:

1. identify at least nine terms associated with the sampling of gaseous pollutants using absorption or adsorption devices.
2. recognize at least seven desirable qualities for a solvent to be used in a physical absoprtion process.
3. name at least two conditions that are necessary for the adequate collection of a gaseous pollutant using a physical absorption process.
4. recognize at least three criteria for selecting an absorbent to be used in a chemical absorption process.
5. identify and describe the effects of at least five sampling conditions on the collection efficiencies of liquid absorbers.
6. recognize the most accurate method for determining the collection efficiency of a liquid absorber.
7. name one advantage and two disadvantages of fritted-glass absorbers.
8. identify and describe the effects of at least four sampling conditions on the adsorption of gaseous pollutants.
9. define adsorption isotherm and associate general adsorption isotherms with chemical and physical adsorption processes.

10. recognize at least seven desirable qualities for an adsorbent to be used in gaseous pollutant sampling.
11. identify characteristics of polar and nonpolar adsorbents.
12. recognize at least four typical problems associated with adsorption air sampling.
13. identify four grab sampling devices and five potential grab sampling problems associated with atmospheric sampling.
14. recognize the freezeout sampling method for ambient air pollutants.

Reading Guidance

- Refer often to the figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section B-2. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any) proceed to Section B-3 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section B-2, please answer the following questions. These will help you determine whether or not you are mastering the material.

For each of questions 1 through 9, match the stated term with its appropriate definition.

1. absorption
2. absorbate
3. absorbent
4. physical absorption
5. adsorption
6. adsorbate
7. adsorbent
8. chemical adsorption
9. physical adsorption

a. the usually reversible process of dissolving a pollutant in a liquid
b. the process by which gases are attracted, concentrated, and retained at a boundary surface
c. adsorption caused by van der Waals' interactions, dipole-dipole interactions, and electrostatic interactions
d. the process of combining gas molecules with an adsorbent to form a surface compound
e. the process of transferring one or more gaseous components into a liquid or solid medium
f. an absorbing medium
g. an absorbed substance
h. an adsorbing medium
i. an adsorbed substance

10. Which of the following is a(are) general absorption mechanism(s)?
    a. physical absorption
    b. chemical absorption
    c. both a and b, above
    d. none of the above
11. Which of the following is a(are) desirable quality(ies) for a solvent to be used in a physical absorption process?
    a. relatively nonvolatile
    b. nonpolar
    c. noncorrosive
    d. both a and b, above
    e. both a and c, above

12. Which of the following conditions is(are) necessary for the adequate collection of a gaseous pollutant using a physical absorption process?
    a. high pollutant solubility in the absorbing medium
    b. small pollutant to absorbing medium ratio
    c. both a and b, above
    d. none of the above

13. Which of the following should be considered when choosing an absorbent for a chemical absorption pollutant sampling process?
    a. pollutant solubility in absorbent
    b. reactive properties of the pollutant and the absorbent
    c. both a and b, above
    d. method of pollutant analysis
    e. all of the above

14. Which of the following affect(s) the collection efficiency of a liquid absorber?
    a. sample air flow rate
    b. bubble size
    c. height of the liquid (absorbent) column
    d. both a and b, above
    e. all of the above

15. The collection efficiency of a liquid absorber ____(?)____ as the flow rate of sample air passing through it increases.
    a. remains the same
    b. increases
    c. decreases

16. The collection efficiency of a liquid absorber ____(?)____ as the sample air bubble size decreases.
    a. remains the same
    b. increases
    c. decreases

17. The collection efficiency of a liquid absorber ____(?)____ as the length of its absorbent column increases.
    a. remains the same
    b. increases
    c. decreases

18. True or False? The sensitivity of the method used to analyze the pollutant collected in a liquid absorber may limit the height of the absorber's liquid column.

19. True or False? The absorbing solution of a liquid absorber should contain an excess of reactant in order to ensure that all the pollutant that is being sampled is collected and that the reaction rate between the pollutant and the reactant is at a maximum.

20. The collection efficiency of a liquid absorber ____(?)____ as the sampled pollutant's solubility in its absorbent increases.
    a. remains the same
    b. increases
    c. decreases

21. The collection efficiency of a liquid absorber ____(?)____ as the sampled pollutant's partial pressure (concentration) increases.
    a. remains the same
    b. increases
    c. decreases

22. The collection efficiency of a liquid absorber usually ____(?)____ as sampling temperature increases.
    a. remains the same
    b. increases
    c. decreases

23. True or False? The most accurate method of determining the collection efficiency of a liquid absorber is testing it under simulated sampling conditions.

24. Which of the following is a(are) general liquid absorber(s)?
    a. fritted-glass absorbers
    b. impingers
    c. both a and b, above
    d. none of the above

25. True or False? Impingers have somewhat higher collection efficiencies than fritted-glass absorbers.

26. Which of the following is a(are) disadvantage(s) of fritted-glass absorbers?
    a. possibility of surface reactions at the frit
    b. fritted-glass absorbers having frit pore sizes of approximately 50 μm or less gradually become clogged with use
    c. both a and b, above
    d. none of the above

27. Which of the following is a(are) general adsorption mechanism(s)?
    a. physical adsorption
    b. chemical adsorption
    c. both a and b, above

28. True or False? Critical temperature may be defined as that temperature above which it is impossible to liquify a gas regardless of the external pressure applied to the gas.

29. The ability of a gas to be adsorbed ____(?)____ as gas boiling point increases.
    a. remains the same
    b. increases
    c. decreases

30. The ability of a gas to be adsorbed ____(?)____ as gas critical temperature increases.
    a. remains the same
    b. increases
    c. decreases

31. True or False? Chemical adsorption is enhanced by higher sampling temperatures.

32. True or False? Physical adsorption is usually limited to monolayer molecular adsorption.

33. True or False? Chemical adsorption usually involves multilayer molecular adsorption.

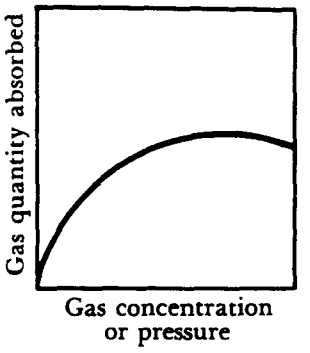
34. Which of the following is an(are) optimum condition(s) for the physical adsorption of a gas?
    a. low adsorbate concentration
    b. large adsorbing surface
    c. no molecules other than adsorbate molecules competing for adsorption sites
    d. high temperature
    e. both b and c, above
    f. all of the above

35. The ability of a gas to be adsorbed ____(?)____ as its concentration increases.
    a. remains the same
    b. increases
    c. decreases

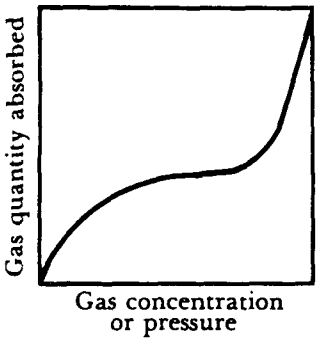
36. True or False? An adsorption isotherm describes the relationship between the quantity of a gas adsorbed at a constant temperature and the gas's concentration or pressure.

37. Which of the general adsorption isotherms depicted below is(are) associated with chemical adsorption?

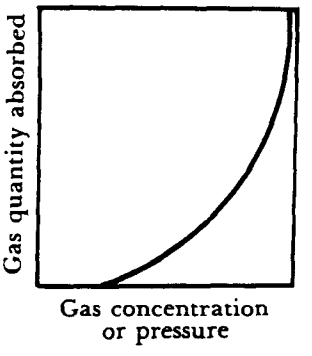
a.



b.



c.



d. all of the above

38. Which of the general adsorption isotherms depicted in question 37 is(are) associated with physical adsorption?
    a. isotherm a
    b. isotherm b
    c. isotherm c
    d. isotherms a and b
    e. isotherms a, b, and c

39. For a gas to be adequately collected by physical adsorption, it must have a molecular weight that is ____(?)____ the molecular weight of the normal components of air.
    a. the same as
    b. larger than
    c. smaller than

40. True or False? For a gas to be adequately collected by physical adsorption, its particles must be small enough to allow Brownian motion or gas velocities to effectively cause contact of the gas with the adsorbent.

41. An adsorbate's adsorption rate ____(?)____ as the number of other substances competing for adsorption sites of the adsorbent increases.
    a. remains the same
    b. increases
    c. decreases

42. Which of the following is ***not*** a desirable quality for an adsorbent?
    a. granular
    b. high resistance to air flow
    c. inert except for a specific adsorbate
    d. resistant to breakage, deterioration, and corrosion
    e. easily activated
    f. provides an easy release of adsorbate
    g. high adsorptive capacity

43. An adsorbent's collection efficiency ____(?)____ as its surface area increases.
    a. remains the same
    b. increases
    c. decreases

44. True or False? Adsorbent activation involves distilling out various impurities from the adsorbent, thus forming a larger free surface area for adsorption.

45. True or False? Adsorbent pore size is an important consideration when selecting an adsorbent to collect a particular adsorbate.

46. True or False? The chemical nature of the surface of an adsorbent does not affect the adsorbent's collection efficiency.

47. Which of the following is a(are) general adsorbent property(ies)?
    a. polar (exhibiting strong polarity)
    b. nonpolar (exhibiting little or no polarity)
    c. both a and b, above

For each of questions 48 through 50, match the adsorbent with its appropriate characteristic(s).

48. polar	a. prefers molecules that have little or no polarity
49. nonpolar	b. strongly prefers polar molecules
50. molecular sieve	c. strongly prefers polar molecules, has very high porosity, is specific for adsorbate size and shape, has high adsorptive capacity.

51. True or False? Nonpolar adsorbents are more selective in adsorbing substances than are polar adsorbents.

52. Which of the following is a(are) characteristic(s) of activated carbon?
    a. polar
    b. absorbs almost all volatile substances
    c. has a high adsorptive capacity
    d. both b and c, above
    e. all of the above

53. Which of the following is a(are) typical adsorption air monitoring problem(s)?
    a. irreversible adsorption of the adsorbate
    b. variable desorption efficiency of the adsorbate during analysis
    c. both a and b, above
    d. in-situ reactions on the adsorbent during sampling
    e. all of the above

54. True or False? Grab sampling consists of removing a small representative portion of a large sample within an interval of a few seconds to a few minutes.

For each of questions 55 through 58, match the grab sampling device with its appropriate diagram.

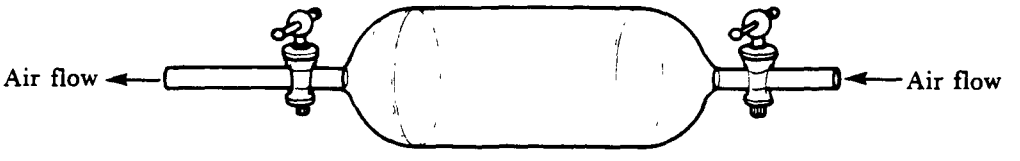
55. evacuated flask

56. liquid-displacement collector

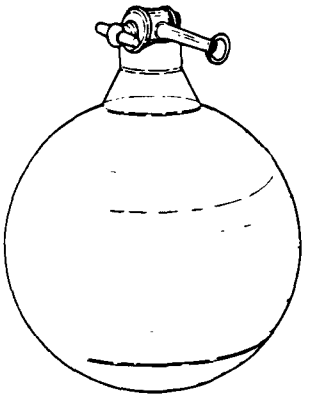
57. gas-displacement collector

58. bag inflation sampler

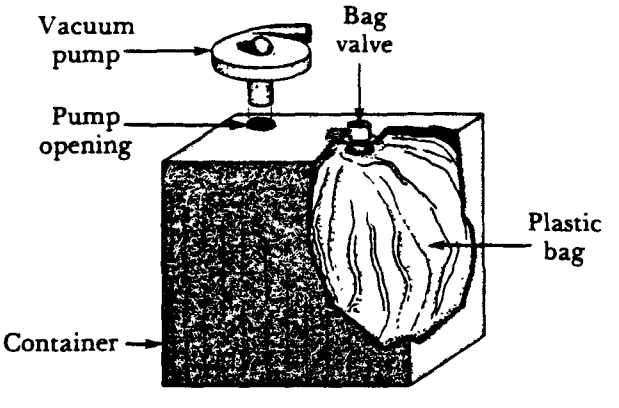
a.



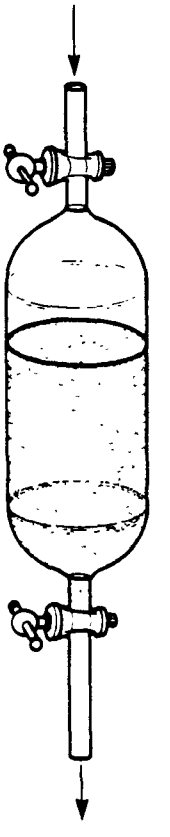
b.



c.



d.



59. Which of the following is a(are) potential sampling problem(s) when using bag grab sampling techniques?
    a. sample contamination and memory effects caused by the bag wall.
    b. sample deterioration over time
    c. both a and b, above
    d. in-situ reactions
    e. all of the above

60. True or False? Usually the most sensitive analytical techniques must be used to detect the small pollutant concentrations found in grab samples.

61. True or False? The freezeout sampling method consists of drawing sample air through collection chambers having progressively lower temperatures. Each component of the sample air condenses to a liquid and is collected in the chamber having a temperature which is approximately equal to or less than its boiling point.

62. Which of the following increase(s) the collection efficiency of a freezeout sampling train?
    a. increasing collection chamber cold surface area
    b. decreasing the flow rate of sample air through the sampling train
    c. both a and b, above
    d. none of the above

63. True or False? Increasing the cold surface area of a freezeout sampling train allows a shorter sample detention time to be used.

64. The sample detention time of a freezeout sampling train ____(?)____ as the flow rate of sample air through the sampling train increases.
    a. remains the same
    b. increases
    c. decreases

Section B-2
Review Exercise Answers

		Page(s) of *Atmospheric Sampling: Student Manual*
1.	e	5-1
2.	g	5-8, 5-9
3.	f	5-1, 5-9
4.	a	5-1
5.	b	5-9
6.	i	5-9
7.	h	5-9
8.	d	5-10
9.	c	5-10
10.	c	5-1
11.	e	5-1
12.	c	5-2
13.	e	5-2
14.	e	5-3
15.	c	5-3, 5-23
16.	b	5-3, 5-23
17.	b	5-3, 5-23
18.	True	5-3, 5-4
19.	True	5-4
20.	b	5-4
21.	b	5-4
22.	c	5-4
23.	True	5-5
24.	c	5-5
25.	False	5-8
26.	c	5-3, 5-7
27.	c	5-9
28.	True	5-10
29.	b	5-10
30.	b	5-10
31.	True	5-11
32.	False	5-11
33.	False	5-11
34.	e	5-11
35.	b	5-11
36.	True	5-12
37.	a	5-12
38.	e	5-12

	Page(s) of *Atmospheric Sampling: Student Manual*
39. b	5-13
40. True	5-14
41. c	5-14
42. b	5-14
43. b	5-14
44. True	5-15
45. True	5-15
46. False	5-15
47. c	5-15, 5-16
48. b	5-16
49. a	5-15
50. c	5-17
51. False	5-16
52. d	5-16
53. e	5-17
54. True	5-26
55. b	5-28
56. d	5-30
57. a	5-29
58. c	5-31
59. e	5-31
60. True	5-31
61. True	5-32
62. c	5-35
63. True	5-35
64. c	5-35

Section B-3

Preparation of Calibration Gases

Reading Assignment

Pages 6-1 through 6-31 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Static systems for the preparation of calibration gases
- Dynamic systems for the preparation of calibration gases
- Preparation of zero air

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with the preparation of calibration gases.

Learning Objectives

At the end of this section, you should be able to:

1. recognize two general systems for the preparation of calibration gases.
2. identify three static systems for the preparation of calibration gases.
3. recognize optimum conditions for the preparation of calibration gases using compressed gas cylinders, bags, and permeation tubes.
4. calculate concentrations of calibration gases prepared using bags, permeation tubes, single dilution systems, and double dilution systems.
5. identify NO_2 and SO_2 permeation tubes.
6. recognize a method of preparing ozone calibration gas.
7. define zero air for air sampling purposes.
8. identify and recognize characteristics of three adsorbents which are commonly used in the preparation of zero air.
9. name three methods of removing water vapor from a gas stream and identify advantages and disadvantages of three adsorbents commonly used.

Reading Guidance

- Preparation of calibration gases using compressed gas cylinders, permeation tubes, and other dynamic calibration devices is discussed in this reading assignment. EPA will verify your compressed gas standards, permeation tube rates, and calibration device outputs at no cost to you. If you would like to use this service, contact: U.S. EPA, Quality Assurance Division, Standards Laboratory, EMSL, MD 77, Research Triangle Park, North Carolina 27711 (telephone: Commercial: (919) 541-2366, FTS: 629-2366).
- Refer often to the equations and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section B-3. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any), take Quiz 2. Follow the directions listed in the Course Introduction section of this guidebook.
- After completing Quiz 2, proceed to Section B-4 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section B-3, please answer the following questions. These will help you determine whether or not you are mastering the material.

1. Which of the following is a(are) general system(s) for the preparation of calibration gases?
   a. static system
   b. dynamic system
   c. both a and b, above
   d. none of the above

2. Which of the following is a(are) general static system(s)?
   a. pressurized system (compressed gas cylinder)
   b. permeation system
   c. bag system
   d. both a and c, above
   e. all of the above

3. Which of the following is an(are) important consideration(s) in preparing calibration gases using compressed gas cylinders?
   a. Due to compressional heating, the cylinder should be allowed to equilibrate to room temperature before reading the gas pressure to be used in calculating the concentration of the calibration gas.
   b. Gases should be thoroughly mixed after their introduction to the gas cylinder to avoid gas layering.
   c. both a and b, above
   d. none of the above

4. ____(?)____ $\mu\ell$ of 100% carbon monoxide must be introduced into a 10ℓ bag to prepare 10ℓ of 50 ppm ($\mu\ell/\ell$) calibration gas.
   a. 5
   b. 0.2
   c. 50
   d. 500

5. Which of the following is an(are) important consideration(s) in preparing calibration gases using bags?
   a. Pollutant gas should be introduced into the stream of the diluent gas as the bag is filling.
   b. Calibration gas will deteriorate over time in a bag.
   c. both a and b, above
   d. none of the above

6. True or False? A permeation tube consists of a tube which is partially filled with a liquified gas. The gas above the liquid is able to permeate through the walls of the tube.

7. The permeation rate of a permeation tube ____(?)____ as the temperature of the permeation tube increases.
   a. remains the same
   b. increases
   c. decreases

8. The pollutant concentration generated by a permeation system ____(?)____ as the diluent gas flow rate of the system increases.
   a. remains the same
   b. increases
   c. decreases

9. If an SO_2 (molecular weight: 64 g/g•mol) permeation tube has a permeation rate of 1.000 μg/min at a temperature of 25 °C and a pressure of 760 mm of mercury. What is the SO_2 concentration (ppm) at EPA's STP conditions generated by a permeation system using the permeation tube and having a total dilution flow rate of 1.000 ℓ/min?
   a. 0.382
   b. 2.62
   c. 0.350
   d. 2.86

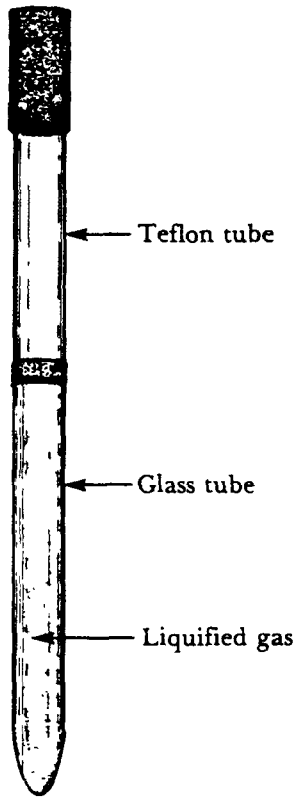
10. Which of the following is an(are) important consideration(s) in using a permeation tube system?
   a. Absorbed moisture on a permeation tube can form acids that may cause tube blistering, thus changing the tube's permeation rate.
   b. Diluent gas which passes over the permeation tube must be kept at a constant temperature and zero humidity in order to maintain a constant permeation rate.
   c. Permeation tubes should be equilibrated at their operating temperatures and zero humidity for two to three days before they are used to generate calibration gas.
   d. both a and b, above
   e. all of the above

For each of questions 11 and 12, match the permeation tube with its appropriate diagram.

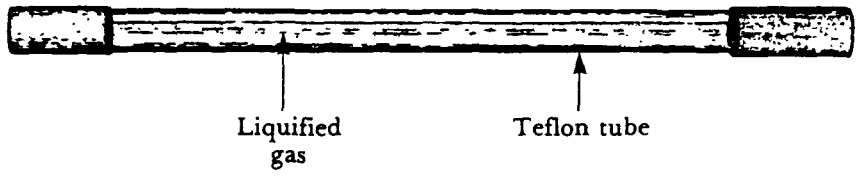
11. NO_2 permeation tube

12. SO_2 permeation tube

a.



b.



13. What is the SO_2 concentration (ppm) generated by a single dilution system if the system's undiluted SO_2 concentration is 100 ppm, the flow rate of undiluted SO_2 is 1 ℓ/min, and the flow rate of diluent gas is 9 ℓ/min?
    a. 90
    b. 11
    c. 10
    d. 100

14. What is the SO_2 concentration (ppm) generated by a double dilution system if the initial dilution system's undiluted SO_2 concentration is 100 ppm, the flow rate of undiluted SO_2 is 1 ℓ/min, and the flow rate of diluent gas is 9 ℓ/min; and the final dilution system's flow rate of diluent gas is 10 ℓ/min?
    a. 0.5
    b. 5.0
    c. 10
    d. 4.5

15. Which of the following is a(are) method(s) of preparing ozone calibration gas?
    a. mixing ozone with nitrogen in compressed gas cylinders
    b. irradiating oxygen with an ultraviolet light
    c. both a and b, above
    d. none of the above

16. True or False? Some calibration gases can be prepared by injecting liquid pollutant into a moving diluent gas stream.

17. True or False? Zero air can be defined as air that is free of contaminants and interferences for a particular analytical technique.

18. True or False? Regardless of its use, zero air always has the same composition.

19. True or False? Activated charcoal can remove ozone, SO_2, NO_2, and many organic vapors from a gas stream.

20. True or False? Neither soda lime nor Ascarite can remove CO_2 from a gas stream.

21. True or False? Ascarite can remove acid gases from a gas stream.

22. Which of the following is a(are) general method(s) of removing water vapor from a gas stream?
    a. adsorption
    b. impaction
    c. condensation
    d. both a and c, above
    e. all of the above

23. Which of the following is a(are) general method(s) of removing gaseous contaminants from a gas stream?
    a. impaction
    b. adsorption
    c. absorption
    d. both b and c, above
    e. both a and b, above

24. Which of the following is a(are) common absorbent(s) for removing water vapor from a gas stream?
    a. silica gel
    b. calcium sulfate
    c. anhydrous magnesium perchlorate
    d. all of the above

For each of questions 25 through 27, match the adsorbent with its advantage(s).

25. silica gel
26. calcium sulfate
27. anhydrous magnesium perchlorate

a. very high efficiency for removing water vapor
b. easy to handle, can be indefinitely regenerated
c. easy to regenerate, has a constant water vapor removal efficiency over a wide range of temperatures

For each of questions 28 through 30, match the adsorbent with its disadvantage(s).

28. silica gel
29. calcium sulfate
30. anhydrous magnesium perchlorate

a. not the most efficient adsorbent for removing water vapor
b. not the most efficient absorbent for removing water vapor, cannot be indefinitely regenerated
c. may explode in the presence of organic vapors, melts when removing water vapor

Section B-3

Review Exercise Answers

		Page(s) of *Atmospheric Sampling: Student Manual*
1.	c	6-1, 6-7
2.	d	6-1, 6-3, 6-4
3.	c	6-2, 6-3
4.	d	6-4
5.	c	6-5, 6-6
6.	True	6-7
7.	b	6-10
8.	c	6-7
9.	a	6-7
10.	e	6-8, 6-9
11.	a	6-12
12.	b	6-12
13.	c	6-14
14.	b	6-15
15.	b	6-16
16.	True	6-17
17.	True	6-18
18.	False	6-18
19.	True	6-20
20.	False	6-21
21.	True	6-24
22.	d	6-25
23.	d	6-19
24.	d	6-25
25.	b	6-26
26.	c	6-27
27.	a	6-26, 6-27
28.	a	6-26, 6-27
29.	b	6-26, 6-27
30.	c	6-27

Section B-4

Introduction to the Reference Methods and Reference Measurement Principles for the Criteria Pollutants, Continuous Air Quality Monitors, and Design of Air Quality Monitoring Networks

Reading Assignment

Pages 7-1 through 9-8 of EPA 450/2-80-004 *APTI Course 435 Atmospheric Sampling: Student Manual.*

Reading Assignment Topics

- Reference methods and reference measurement principles for the criteria pollutants
- Continuous air quality monitors
- Design of air quality monitoring networks

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with the reference methods and reference measurement principles for the criteria pollutants, continuous air quality monitors, and the design of air quality monitoring networks.

Learning Objectives

At the end of this section, you should be able to:

1. locate the National Ambient Air Quality Standards (NAAQS), descriptions of the reference methods and reference measurement principles, and designation requirements for reference and equivalent methods in the *Code of Federal Regulations.*
2. identify the two general types of reference and equivalent methods.
3. describe requirements for the designation of automated reference methods and manual and automated equivalent methods.
4. identify the reference method or reference measurement principle for each criteria pollutant.

5. identify advantages of using continuous instrumental methods for monitoring ambient air quality.
6. recognize and identify advantages and disadvantages of coulometric, amperometric, second derivative spectroscopic, flame photometric, fluorescence, chemiluminescence, ultraviolet photometric, and nondispersive infrared air quality monitors.
7. identify two major subsystems of an air quality monitoring network.
8. identify major considerations in designing an air quality monitoring network.
9. associate typical spatial scales of representativeness with their corresponding linear dimensions.

Reading Guidance

- Two correspondence courses concerning the siting of ambient air quality monitors, *APTI Course 436 Site Selection for the Monitoring of SO_2 and TSP in Ambient Air* and *APTI Course 437 Site Selection for the Monitoring of CO and Photochemical Pollutants in Ambient Air* have been prepared for EPA. If you would like information concerning these courses, contact EPA's Air Pollution Training Institute at the address or phone number given in the Course Introduction section of this guidebook.
- Refer often to the equations and figures of the assigned reading material as you progress through the assignment.
- When you have finished the reading assignment, complete the review exercise for Section B-4. It begins on the following page.
- After you have answered the review exercise questions, check your answers. The correct answers are listed on the page immediately following the review exercise.
- For any review exercise questions that you answered incorrectly, review the page(s) of the reading assignment indicated on the answers page.
- After you have reviewed your incorrect answers (if any) take the final examination for the course. Follow the directions listed in the Course Introduction section of this guidebook.
- Your course grade results will be mailed to you.

Review Exercise

Now that you've completed the assignment for Section B-4, please answer the following questions. These will help you determine whether or not you are mastering the material.

For each of questions 1 through 3, match the item with its location in the *Code of Federal Regulations*.

1. National Ambient Air Quality Standards (NAAQS)
2. descriptions of the reference methods and reference measurement principles for monitoring pollutants having NAAQS
3. designation requirements for reference and equivalent methods

a. Title 40 Part 53
b. Title 40 Part 50
c. Appendixes of Title 40 Part 50

4. Which of the following is a(are) general type(s) of reference methods?
   a. manual method
   b. automated method
   c. both a and b, above
   d. none of the above
5. Which of the following is a(are) general type(s) of equivalent methods?
   a. manual method
   b. automated method
   c. both a and b, above
   d. none of the above
6. True or False? In order to be designated an equivalent method, a manual method must demonstrate a consistent relationship to the manual reference method or to the automated reference methods.
7. Which of the following is(are) necessary for the designation of an automated equivalent method?
   a. Performance specifications for automated methods must be met.
   b. A measurement principle different from the reference measurement principle must be used.
   c. both a and b, above
   d. none of the above
8. Which of the following is(are) necessary for the designation of an automated reference method?
   a. Performance specifications for automated methods must be met.
   b. The reference measurement principle must be used.
   c. both a and b, above
   d. none of the above

For each of questions 9 through 15, match the pollutant with the description of its reference method or reference measurement principle.

9. sulfur dioxide	a. pararosaniline method
10. nitrogen dioxide	b. chemiluminescence with ozone
11. carbon monoxide	c. chemiluminescence with ethylene
12. lead	d. high volume sampler, gravimetric analysis
13. total suspended particulate matter	e. high volume sampler, atomic absorption spectrophotometric analysis
14. nonmethane hydrocarbons	f. nondispersive infrared spectrometry
15. ozone	g. gas chromatography with a flame ionization detector

16. True or False? Temperature instability of the chemical complex formed during sampling is a potential problem in using the pararosaniline method.

17. True or False? A flame ionization detector responds the same to all hydrocarbon compounds.

18. Which of the following is a(are) potential problem(s) when using the lead reference method?
    a. nonuniform distributions of lead on high volume sampler filters when sampling near heavily traveled roadways
    b. chemical and light scattering interferences during lead analysis
    c. both a and b, above
    d. none of the above

19. Which of the following is an(are) advantage(s) of using continuous instrumental methods for monitoring ambient air quality?
    a. real-time data output
    b. in-situ measurements
    c. ability to transmit data directly into computer systems
    d. both a and c, above
    e. all of the above

For each of questions 20 through 27, match the instrumental method with its description.

20. nondispersive infrared
21. coulometric
22. flame photometric
23. fluorescence
24. amperometric
25. second derivative spectroscopic
26. chemiluminescence
27. ultraviolet photometric

a. uses an electrical charge generated by oxidation-reduction reactions occurring in an electrolytic cell to measure gaseous pollutant concentration
b. uses an electrical current generated by oxidation-reduction reactions in an electrolytic cell to measure gaseous pollutant concentration
c. relates the slope and curvature characteristics of energy absorption bands to gaseous pollutant concentration
d. uses the energy emitted by a pollutant in a hydrogen-rich flame to measure the pollutant's concentration
e. uses the energy emitted due to electronic transitions to measure pollutant concentration
f. uses the light emitted due to the reaction of a gaseous pollutant with a reagent gas to measure the pollutant's concentration
g. uses the absorption of energy due to electronic transitions to measure pollutant concentration
h. uses the absorption of infrared energy to measure pollutant concentration

For each of questions 28 through 31, match the instrumental method with its advantage(s).

28. flame photometric
29. coulometric/amperometric
30. second derivative spectroscopic
31. fluorescence

a. highly specific for pollutant monitored, no support gases are needed for its operation
b. no support gases are needed for its operation
c. no support gases are needed for its operation, relatively insensitive to temperature and sample air flow variations
d. highly specific for sulfur compounds, no chemical solutions are needed for its operation, low maintenance requirements, high sensitivity for sulfur compounds, fast response

For each of questions 32 through 35, match the instrumental method with its disadvantage(s).

32. fluorescence
33. second derivative spectroscopic
34. flame photometric
35. coulometric/amperometric

a. must use a scrubber to remove sample air components that react with halogens
b. complexity of measurement principle
c. if monitoring for a specific sulfur compound, must use a scrubber to remove other sulfur compounds from the sample air; potential carbon dioxide interference; must use hydrogen
d. must use a scrubber to remove hydrocarbons from the sample air

36. Which of the following is a(are) potential interferent(s) due to broad band absorption in the nondispersive infrared monitoring of carbon monoxide?
    a. carbon dioxide
    b. water vapor
    c. sulfur dioxide
    d. both a and b, above
    e. all of the above

37. True or False? The "negative filtering" technique used in the nondispersive infrared monitoring of carbon monoxide minimizes interference due to broad band absorption by causing the ratio of infrared absorbance in the instrument's detector chambers to be independent of the sample air's interferent concentration.

38. Which of the following is a(are) major subsystem(s) of an air quality monitoring network?
    a. sensor system
    b. data system
    c. data recording and transmission system
    d. data processing system
    e. both a and b, above
    f. all of the above

39. Which of the following is a(are) major subsystem(s) of a data system?
    a. data recording and transmission system
    b. data processing system
    c. both a and b, above
    d. none of the above

40. True or False? Before designing an air quality monitoring network, the uses of the data that will be generated by the network should be established.

For each of questions 41 through 45, match the spatial scale of representativeness with its corresponding dimension.

41. microscale	a. 100 meters to 0.5 kilometer
42. middle scale	b. greater than 50 kilometers
43. neighborhood scale	c. less than 100 meters
44. urban scale	d. 4 to 50 kilometers
45. regional scale	e. 0.5 to 4 kilometers

46. Which of the following should be considered when determining what pollutants to monitor?
    a. pollutants having air quality standards
    b. pollutants suspected of being hazardous to public health/welfare
    c. both a and b, above
    d. none of the above

47. For which of the following is the use of reference or equivalent methods usually required?
    a. when monitoring for State Implementation Plan (SIP) purposes
    b. when monitoring for Prevention of Significant Deterioration (PSD) purposes
    c. both a and b, above
    d. none of the above

48. Maintenance and calibration information concerning air quality monitors can be obtained from which of the following?
    a. monitor manufacturers
    b. monitor users
    c. maintenance and calibration records
    d. all of the above

49. True or False? Most of the EPA ambient air monitoring regulations are found in Title 40 Part 58 of the *Code of Federal Regulations.*

50. True or False? The major problem in designing data systems is usually trying to get a balance of manpower and equipment.

51. True or False? When designing a data transmission system, the speed with which the data will be used should be determined.

52. Which of the following is a(are) component(s) of a data processing system?
    a. data format
    b. data validation
    c. data analysis
    d. both a and c, above
    e. all of the above

53. True or False? A data format is a systematic listing of the data recorded.

54. True or False? A data format should be clearly defined and well documented.

55. True or False? The SAROAD data format is available from EPA.

56. True or False? Data validation should be performed as closely as possible in place and time to the collection of the data.

57. True or False? Data should be analyzed before they are validated.

58. Which of the following should be considered when designing a data storage system?
    a. Physical deterioration of the data must be prevented.
    b. Data should be stored logically.
    c. The storage system must be secure to provide a legal chain of custody.
    d. both a and b, above
    e. all of the above

59. Which of the following should be considered when designing a data retrieval system?
    a. Proper personnel should have easy access to the data.
    b. Retrieval procedures should be systematic.
    c. both a and b, above

60. True or False? An air quality monitoring network needs a comprehensive quality assurance program.

61. True or False? The gas filter correlation technique greatly reduces interference effects associated with nondispersive infrared CO analyzers.

Section B-4
Review Exercise Answers

		Page(s) of *Atmospheric Sampling: Student Manual*
1.	b	7-1
2.	c	7-1
3.	a	7-1
4.	c	7-1
5.	c	7-1
6.	True	7-2
7.	c	7-2, 7-3
8.	c	7-3
9.	a	7-2, 7-3
10.	b	7-2, 7-5
11.	f	7-2, 7-6
12.	e	7-2, 7-8
13.	d	7-2, 7-6
14.	g	7-2, 7-8
15.	c	7-2, 7-7
16.	True	7-4
17.	False	7-8
18.	c	7-8, 7-9
19.	e	8-1
20.	h	8-14
21.	a	8-21
22.	d	8-2
23.	e	8-4
24.	b	8-21
25.	c	8-12
26.	f	8-7
27.	g	8-10
28.	d	8-4
29.	b	8-23
30.	a	8-13
31.	c	8-5
32.	d	8-6
33.	b	8-14
34.	c	8-4
35.	a	8-24
36.	d	8-15
37.	True	8-16, 8-17
38.	e	9-1

Page(s) of *Atmospheric Sampling: Student Manual*

39. c 9-1
40. True 9-1
41. c 9-3
42. a 9-3
43. e 9-3
44. d 9-3
45. b 9-3
46. c 9-3
47. c 9-4
48. d 9-4
49. True 9-5
50. True 9-6
51. True 9-6
52. e 9-6
53. True 9-6
54. True 9-6
55. True 9-7
56. True 9-7
57. False 9-7
58. e 9-7
59. c 9-8
60. True 9-8
61. True 8-20

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16. ABSTRACT

This Guidebook was developed for use in the Air Pollution Training Institute's Correspondence Course 434, "Introduction to Ambient Air Monitoring". It contains reading assignments and review exercises covering the following topics:

- Introduction to Atmospheric Sampling
- Basic Properties of Gases
- Air Movers and Air Measuring Instruments
- Ambient Sampling of Particulate Matter
- Manual Sampling of Ambient Gaseous Pollutants
- Preparation of Calibration Gases
- Introduction to the Reference Methods and Reference Measurement Principles for the Criteria Pollutants
- Introduction to Continuous Air Quality Monitors
- Introduction to the Design of Air Quality Monitoring Networks
- Introduction to Pertinent Statistical Techniques for Air Monitoring

This Guidebook is designed for use in conjunction with "APTI Course 435 Atmospheric Sampling: Student Manual Second Edition" (EPA 450/2-80-004).

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