SCIENCE TEST

35 Minutes—40 Questions

DIRECTIONS: There are several passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

You are NOT permitted to use a calculator on this test.

Passage I

Wood mice (a species of mammal) typically forage for food at night. Their foraging behavior can be affected by environmental factors, including the presence of moonlight and the presence of shelter (such as shrubs). Four students each proposed a hypothesis describing how the foraging behavior of wood mice is affected by the presence of moonlight and shelter. Then they conducted an experiment to test their hypotheses.

Student 1

Wood mice are more likely to forage when moonlight is absent than when moonlight is present. The absence of moonlight decreases the chance that a wood mouse will be captured by a predator. Therefore, the number of wood mouse visits to a foraging site will be greater during the new moon than during the full moon. Shelter has no effect on foraging behavior.

Student 2

Wood mice are more likely to forage at sites with shelter than at sites without shelter. The presence of shelter decreases the chance that a wood mouse will be captured by a predator. Therefore, the number of wood mouse visits to a foraging site will be greater when shelter is present than when shelter is absent. Moonlight has no effect on foraging behavior.

Student 3

Wood mice are more likely to forage at sites with shelter than at sites without shelter, and they are more likely to forage when moonlight is absent than when moonlight is present. Both the presence of shelter and the absence of moonlight decrease the chance that a wood mouse will be captured by a predator. Therefore, the greatest number of wood mouse visits will be to foraging sites with shelter during the new moon.

Student 4

The foraging behavior of wood mice is not affected by the presence of shelter or moonlight. These factors do not affect the chance that a wood mouse will be captured by a predator, and therefore do not affect the number of wood mouse visits to a foraging site.

Experiment

Over the course of several months, the students counted the number of wood mouse visits to a foraging site with shelter and a foraging site without shelter during the new moon and during the full moon (see table).

Shelter present?	Number of visits during new moon	Number of visits during full moon
Yes	1,003	882
No	285	191

Table adapted from Ramón Perea et al., "Moonlight and Shelter Cause Differential Seed Selection and Removal by Rodents." ©2011 by The Association for the Study of Animal Behaviour.

1. A scientist claimed that adding shrubs to a foraging site will increase the number of wood mouse visits to that site. This claim is consistent with the hypothesis or hypotheses of which of the students?

   A. Student 2 only
   B. Students 1 and 4 only
   C. Students 2 and 3 only
   D. Students 1, 2, 3, and 4

2. Based on Student 3's hypothesis, a wood mouse would be *least* likely to be captured by a predator during the:

   F. new moon at a foraging site with shelter.
   G. new moon at a foraging site without shelter.
   H. full moon at a foraging site with shelter.
   J. full moon at a foraging site without shelter.

3. Consider the results of the experiment, during the new moon and during the full moon, for the site without shelter. Are these results consistent with the hypothesis of Student 1 ?

   A. Yes; there were fewer visits during the new moon than during the full moon.
   B. Yes; there were more visits during the new moon than during the full moon.
   C. No; there were fewer visits during the new moon than during the full moon.
   D. No; there were more visits during the new moon than during the full moon.

4. Before the experiment, which student would most likely have predicted that the number of wood mouse visits would be approximately the same for all the conditions that were tested?

   F. Student 1
   G. Student 2
   H. Student 3
   J. Student 4

5. Over the course of several months, a scientist conducted a study to determine if the number of wood mouse visits to a foraging site varied with moonlight brightness. The results of the study are shown in the following figure.

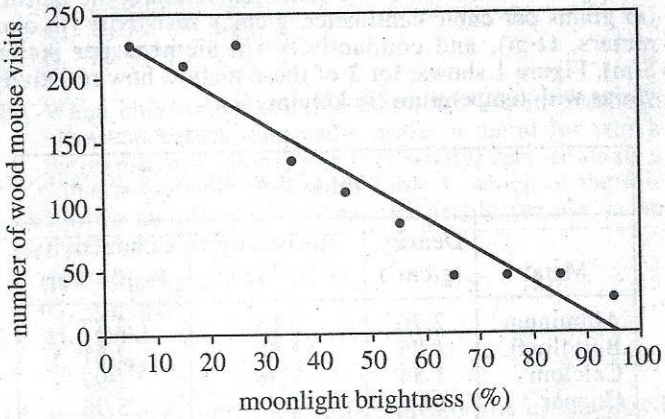


Figure adapted from Ramón Perea et al., "Moonlight and Shelter Cause Differential Seed Selection and Removal by Rodents." ©2011 by The Association for the Study of Animal Behaviour.

These results are consistent with the hypothesis or hypotheses of which of the students?

   A. Student 1 only
   B. Student 4 only
   C. Students 1 and 3 only
   D. Students 2 and 3 only

6. The results of the experiment are most consistent with the hypothesis of which student?

   F. Student 1
   G. Student 2
   H. Student 3
   J. Student 4

7. Which of the following questions was addressed by each of the hypotheses but cannot be directly answered by the results of the experiment?

   A. Does the presence of moonlight and shelter affect the chance that a wood mouse will be captured by a predator?
   B. Does the presence of moonlight and shelter affect the chance that a wood mouse will construct a nest at a foraging site?
   C. Does a foraging site receive more visits from wood mice during a new moon than during a full moon?
   D. Does a foraging site with shelter receive more visits from wood mice than does a foraging site without shelter?

Passage II

Resistivity is the tendency of a material to oppose the flow of an electric current, whereas *conductivity* is the ability of a material to carry an electric current. Table 1 lists, for each of 12 metals at the same temperature, the density (in grams per cubic centimeter, g/cm^3), resistivity (in ohm meters, Ω·m), and conductivity (in siemens per meter, S/m). Figure 1 shows, for 3 of these metals, how resistivity varies with temperature (in kelvins, K).

Table 1

Metal	Density (g/cm^3)	Resistivity ($\times 10^{-8}$ Ω·m)	Conductivity ($\times 10^7$ S/m)
Aluminum	2.70	2.65	3.77
Beryllium	1.85	3.56	2.81
Calcium	1.54	3.36	2.97
Copper	8.96	1.68	5.96
Gold	19.3	2.21	4.52
Iron	7.87	9.61	1.03
Lithium	0.530	9.28	1.08
Magnesium	1.74	4.39	2.23
Potassium	0.890	7.20	1.39
Silver	10.5	1.59	6.30
Sodium	0.970	4.88	2.05
Tungsten	19.3	5.39	1.86

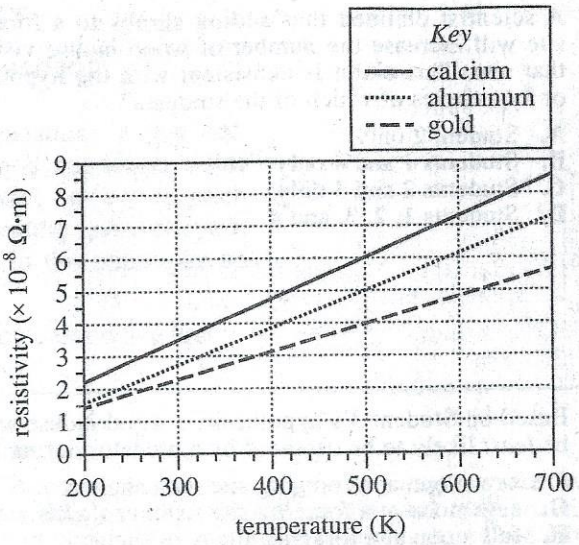


Figure 1

8. According to Figure 1, at a temperature of 600 K, which of calcium, aluminum, and gold has(have) a resistivity greater than 7×10^{-8} Ω·m ?

   F. Calcium only
   G. Aluminum only
   H. Calcium and aluminum only
   J. Calcium and gold only

9. Based on Table 1, of the following 4 metals, which has the greatest ability to carry electric current?

   A. Beryllium
   B. Iron
   C. Magnesium
   D. Tungsten

10. According to Figure 1, approximately how many times as great is the resistivity of aluminum at 600 K than at 320 K ?

    F. $\frac{1}{4}$
    G. $\frac{1}{2}$
    H. 2
    J. 4

11. Suppose that a certain metal has a resistivity of 3.46×10^{-8} Ω·m. Based on Table 1, the conductivity of this metal is most likely closest to which of the following?

    A. 1.69×10^{-7} S/m
    B. 2.89×10^{-7} S/m
    C. 1.69×10^{7} S/m
    D. 2.89×10^{7} S/m

12. When choosing a suitable metal for use in overhead electrical cables, engineers prefer a metal for which the expression (density) × (resistivity) has as small a value as possible. Based on Table 1, which of the following metals would be most suitable for use in an overhead cable?

    F. Aluminum
    G. Copper
    H. Gold
    J. Silver

13. Based on Figure 1, the resistivities of the metals listed in Table 1 were most likely measured at a temperature closest to which of the following?

    A. 200 K
    B. 300 K
    C. 400 K
    D. 500 K

Passage III

When *Moina micrura* (microscopic aquatic crustaceans) are exposed to unfavorable environmental conditions, they produce *ephippia* (specialized eggs that each contain a dormant embryo). The embryos remain dormant until the ephippia are exposed to favorable environmental conditions that cause the ephippia to hatch. Two experiments examined how pH and light intensity affect the hatching of *M. micrura* ephippia.

Experiment 1

Each of 15 identical beakers received 50 mL of water and 120 freshly laid *M. micrura* ephippia. The beakers were then equally divided into 5 groups (Groups L–P). For each group of beakers, the water was maintained at 1 of 5 different pH values (see Table 1).

Table 1

Group	pH
L	3.0
M	5.0
N	7.0
O	9.0
P	11.0

Each beaker was then incubated at 27°C and received 12 hr of light per day at a light intensity of 650 lux. At the end of 7 days, the number of ephippia that had hatched in each beaker was counted, and the average number of ephippia hatched in each group was calculated (see Figure 1).

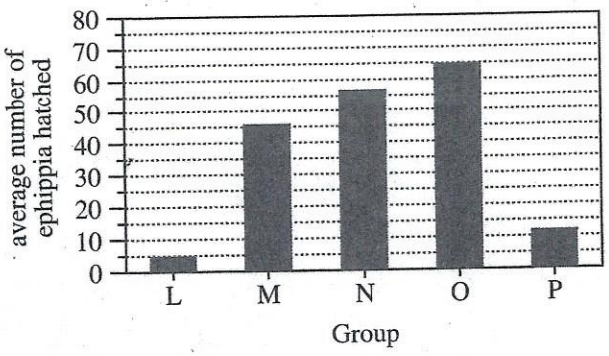


Figure 1

Experiment 2

Each of 20 identical beakers received 50 mL of water and 120 freshly laid *M. micrura* ephippia. The beakers were then equally divided into 5 groups (Groups Q–U). Each beaker was incubated at 25°C, and the water in each beaker was maintained at a pH of 7.0. Group Q was kept in the dark, and each of Groups R–U received 12 hr of light per day at 1 of 4 different light intensities (see Table 2).

Table 2

Group	Light intensity (lux)
Q	0
R	300
S	650
T	850
U	1,300

At the end of 7 days, the average number of ephippia hatched in each group was determined as in Experiment 1 (see Figure 2).

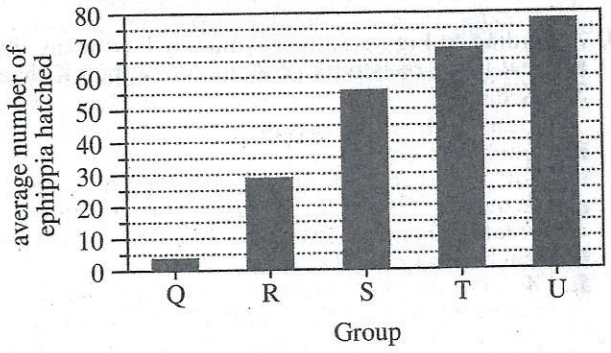


Figure 2

Figures adapted from N. E. T. Rojas, M. A. Marins, and O. Rocha, "The Effect of Abiotic Factors on the Hatching of *Moina micrura* Kurz, 1874 (Crustacea: Cladocera) Ephippial Eggs." ©2001 by the International Institute of Ecology.

14. According to the results of Experiment 2, among the 5 groups tested, as the light intensity increased, the average number of ephippia hatched:

F. decreased only.
G. increased only.
H. decreased and then increased.
J. increased and then decreased.

15. Suppose that a scientist wants to develop an artificial system for hatching *M. micrura* ephippia in a laboratory environment. Based on the results of Experiment 1, which of the pH values tested would most likely maximize the chances of hatching *M. micrura* ephippia in this system?

A. 5.0
B. 7.0
C. 9.0
D. 11.0

16. Consider the units of measurement "mL" and "lux" in Experiment 2. Which of the following phrases best describes the quantities represented by those units?

	mL	lux
F.	mass of water	duration of light exposure
G.	mass of water	light intensity
H.	volume of water	duration of light exposure
J.	volume of water	light intensity

17. Consider the statement "The number of ephippia that hatched, on average, was greater for the ephippia kept in the dark than it was for the ephippia exposed to light." Do the results of Experiment 2 support this statement?

A. Yes; the average number of ephippia hatched in Group R, Group S, Group T, or Group U was greater than the average number of ephippia hatched in Group Q.
B. Yes; the average number of ephippia hatched in Group Q, Group R, Group S, or Group T was greater than the average number of ephippia hatched in Group U.
C. No; the average number of ephippia hatched in Group R, Group S, Group T, or Group U was greater than the average number of ephippia hatched in Group Q.
D. No; the average number of ephippia hatched in Group Q, Group R, Group S, or Group T was greater than the average number of ephippia hatched in Group U.

18. Which of the following pieces of equipment was most likely used to collect the data that were averaged to produce Figures 1 and 2 ?

F. Electronic balance
G. Light microscope
H. Metric ruler
J. pH meter

19. In Experiment 1, the *total* length of time a group of beakers was exposed to light was:

A. 12 hr.
B. 24 hr.
C. 84 hr.
D. 168 hr.

20. Consider the claim "The length of time that the beakers in a group were incubated affected the average number of ephippia hatched in the group." Can this claim be evaluated on the basis of the results of the 2 experiments?

F. Yes, because incubation time was different for each group.
G. Yes, because incubation time was the same for all the groups.
H. No, because incubation time was different for each group.
J. No, because incubation time was the same for all the groups.

Passage IV

Atmospheres (atm), *torr*, and *kilopascals* (kPa) are common units of pressure. Figure 1 can be used to convert between torr and kPa. A pressure of 1 atm is indicated in Figure 1.

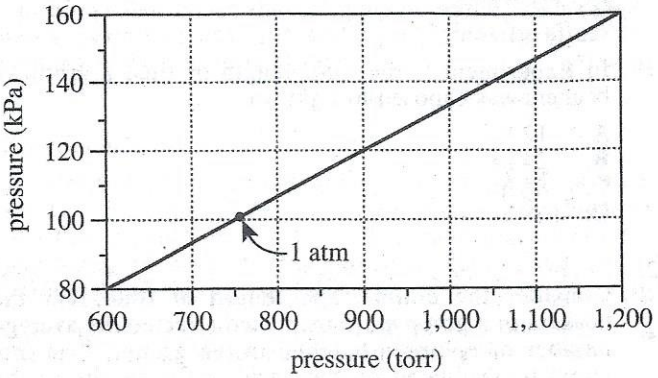


Figure 1

Figure 2 shows how boiling point (*BP*) varies with atmospheric pressure for 3 compounds: acetaldehyde, acetone, and pentane. The unit of pressure is torr.

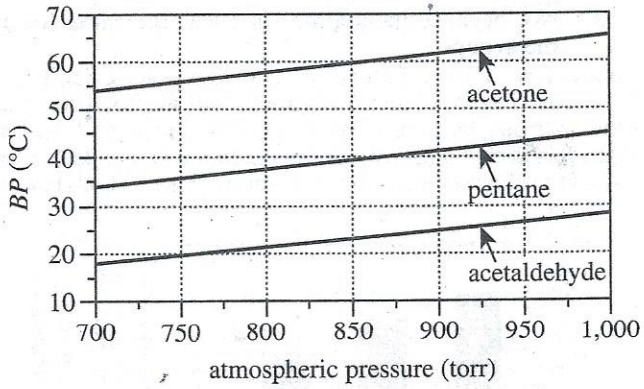


Figure 2

Figure 3 shows how *BP* varies with atmospheric pressure for 3 other compounds: ethanol, methanol, and methyl acetate. The unit of pressure is kPa.

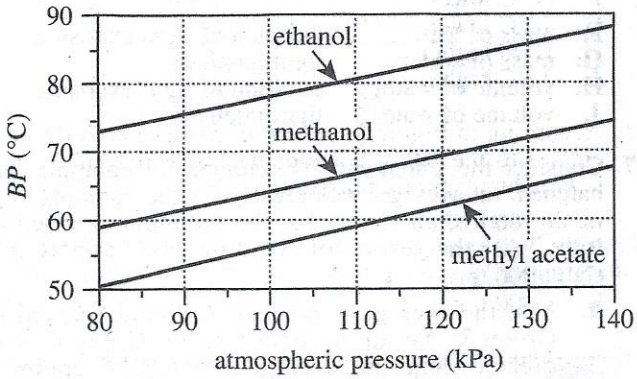
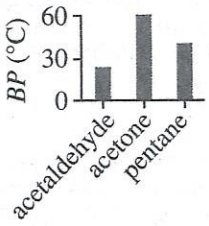


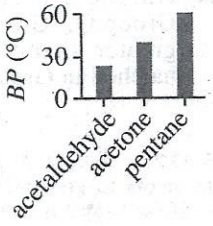
Figure 3

21. According to Figure 2, which of the following graphs best shows the *BP*s of acetaldehyde, acetone, and pentane at 850 torr?

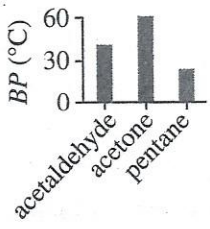
A.



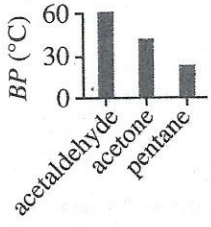
C.



B.



D.



22. According to Figure 3, at 110 kPa, the *BP* of methyl acetate is approximately how much lower than or higher than the *BP* of ethanol?

F. 20°C lower
G. 10°C lower
H. 10°C higher
J. 20°C higher

23. According to Figure 2, the *BP* of pentane at 700 torr is closest to the *BP* of acetaldehyde at which of the following atmospheric pressures?

A. 700 torr
B. 800 torr
C. 900 torr
D. 1,000 torr

24. A compound's *standard boiling point* is the temperature at which the compound boils when the atmospheric pressure is 1 atm. Based on Figures 1 and 2, the standard boiling point of pentane is approximately:

F. 21°C.
G. 36°C.
H. 57°C.
J. 66°C.

25. Based on Figure 1, a pressure of 2 atm would correspond to a pressure in torr that is:

A. less than 700 torr.
B. between 700 torr and 950 torr.
C. between 950 torr and 1,200 torr.
D. greater than 1,200 torr.

26. Suppose a sample of methanol is in a chamber maintained at 60°C and 110 kPa. Based on Figure 3, if the temperature is kept constant, which of the following changes in the pressure will cause the sample to boil?

F. A decrease of 30 kPa
G. A decrease of 20 kPa
H. An increase of 20 kPa
J. An increase of 30 kPa

Passage V

Multivitamin (MV) tablets often contain iron in the form of Fe^{2+}. In aqueous solution, Fe^{2+} does not absorb visible light. However, when *o*-phenanthroline (*o*-phen) is present, it interacts with Fe^{2+} to form an orange-colored complex, which absorbs visible light at a wavelength of 508 nanometers (nm).

Students measured the absorbance at 508 nm—the A_{508}—of 6 solutions having known Fe^{2+} concentrations and then determined the Fe^{2+} content of 4 brands of MV tablets (Brands A–D).

Experiment 1

Steps 1–5 were performed 6 times:

1. A certain volume of an aqueous stock solution having a concentration of 0.04 mg Fe^{2+}/mL was placed in a 100.0 mL flask.
2. Two mL of *hydroquinone* solution was added to the flask to stabilize Fe^{2+}.
3. Three mL of *o*-phen solution was added to the flask.
4. The contents of the flask were diluted with H_2O to form a solution of 100.0 mL.
5. The A_{508} of the solution formed was measured with a colorimeter.

Table 1 shows, for each of the 6 solutions formed (Solutions 1–6), the volume of stock solution used, the Fe^{2+} concentration, and the A_{508}.

Table 1

Solution	Volume of stock solution (mL)	Fe^{2+} concentration (mg/mL)	A_{508}
1	0	0.0000	0.000
2	1	0.0004	0.080
3	2	0.0008	0.159
4	3	0.0012	0.239
5	4	0.0016	0.318
6	5	0.0020	0.398

Experiment 2

Each of Brands A–D was analyzed by crushing 1 tablet, dissolving the powder in H_2O to form a 100.0 mL solution, placing 1 mL of the solution into a flask, and then performing Steps 2–5. From the results, each brand's iron (Fe^{2+}) content, in mg/tablet, was calculated. Table 2 compares, for each brand, the calculated content with the iron (Fe^{2+}) content stated on the label.

Table 2

Brand of MV tablet	Stated iron (Fe^{2+}) content (mg/tablet)	Calculated iron (Fe^{2+}) content (mg/tablet)
A	18	16.5
B	8	8.9
C	18	19.1
D	5	5.2

27. Suppose that in Experiment 1, a seventh solution had been formed, beginning with 6 mL of the stock solution. Based on Table 1, if the A_{508} of the seventh solution had been measured, it would most likely have been closest to which of the following?

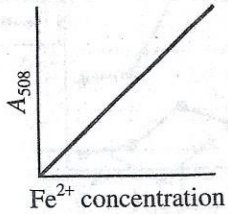
A. 0.318
B. 0.398
C. 0.480
D. 0.560

28. Based on Tables 1 and 2, the solution of which brand of MV tablet most likely had the greatest A_{508} value in Experiment 2 ?

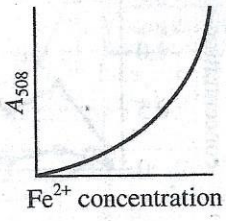
F. Brand A
G. Brand B
H. Brand C
J. Brand D

29. Which of the following graphs best shows the relationship between Fe^{2+} concentration and A_{508} in Experiment 1 ?

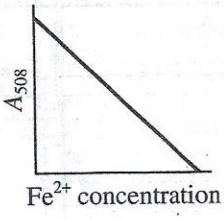
A.



C.



B.



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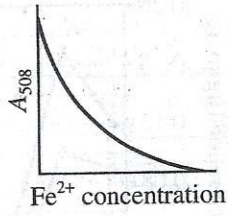

30. Consider the stock solution that was placed in a flask in Step 1. Was this solution more likely orange or colorless?

F. Orange, because it would have absorbed visible light.
G. Orange, because it would not have absorbed visible light.
H. Colorless, because it would have absorbed visible light.
J. Colorless, because it would not have absorbed visible light.

31. In Experiment 1, was the volume of H_2O that had to be added to the flask in Step 4 to form Solution 2 greater than or less than the volume of H_2O that had to be added to the flask in Step 4 to form Solution 5 ?

A. Greater, because the stock solution accounted for a larger volume of Solution 2 than of Solution 5.
B. Greater, because the stock solution accounted for a smaller volume of Solution 2 than of Solution 5.
C. Less, because the stock solution accounted for a smaller volume of Solution 2 than of Solution 5.
D. Less, because the stock solution accounted for a larger volume of Solution 2 than of Solution 5.

32. What was the purpose of Step 3, the addition of *o*-phen to the flask? The *o*-phen interacted with:

F. hydroquinone to stabilize Fe^{2+}.
G. hydroquinone to form an orange-colored complex.
H. Fe^{2+} to stabilize hydroquinone.
J. Fe^{2+} to form an orange-colored complex.

33. Experiments 1 and 2 were most likely related to each other in which of the following ways?

A. The A_{508} values of Solutions 1–6 measured in Experiment 1 were used to determine the Fe^{2+} contents of Brands A–D in Experiment 2.
B. The Fe^{2+} contents of Brands A–D calculated in Experiment 2 were used to determine the A_{508} values of Solutions 1–6 in Experiment 1.
C. The A_{508} values of Solutions 1–6 measured in Experiment 2 were used to determine the Fe^{2+} contents of Brands A–D in Experiment 1.
D. The Fe^{2+} contents of Brands A–D calculated in Experiment 1 were used to determine the A_{508} values of Solutions 1–6 in Experiment 2.

Passage VI

A study was done in a large city in Asia during the spring to examine the composition of airborne dust particles on 5 days of fair weather and on 5 days of dust storms. There was no precipitation on any of the study days.

Study

A device called an *impactor* (see Figure 1) was installed on the roof of a 4-story building in the center of the city. To collect airborne dust particles, the impactor drew in air at a constant rate of 1.1 L/min. A series of 8 filters inside the impactor removed particles from the air. Each filter had openings of a different uniform diameter to allow for the collection of particles belonging to 1 of 8 different size ranges, measured in micrometers (μm).

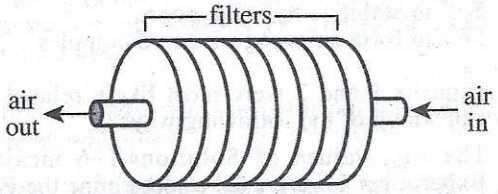

Figure 1

On each of the selected days, the impactor was operated continuously over a period that began at 9 a.m. At 3 p.m., the impactor was turned off, and the collected particles belonging to each size range were removed and then analyzed for 4 elements: silicon (Si), iron (Fe), sulfur (S), and copper (Cu). The average concentration of each element, in micrograms per cubic meter of air ($\mu g/m^3$), for the fair weather days and for the dust storm days are shown in Figures 2 and 3, respectively, for each size range.

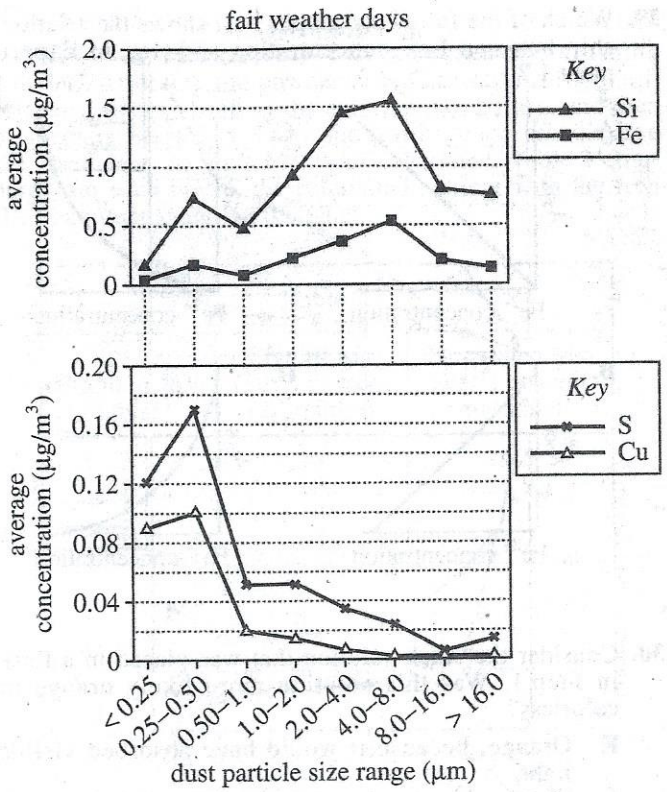

Figure 2

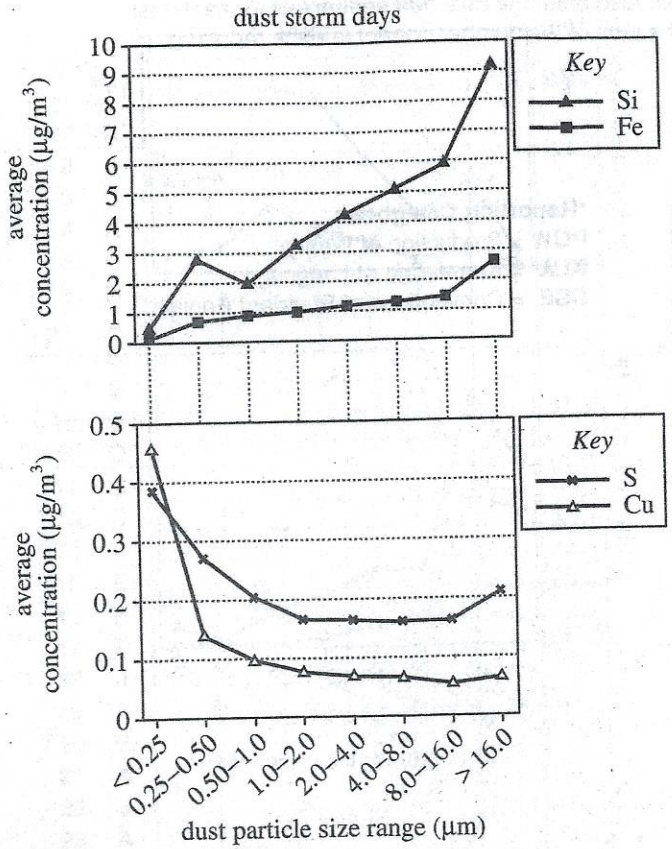

Figure 3

Figures 2 and 3 adapted from Renjian Zhang et al., "The Elemental Composition of Atmospheric Particles at Beijing during Asian Dust Events in Spring 2004." ©2010 by the Taiwan Association for Aerosol Research.

34. Consider the results of the study for the dust storm days. Did the larger dust particles (> 2.0 μm) or the smaller dust particles (< 2.0 μm) have the greater average concentrations of Si and Fe, and did the larger dust particles or the smaller dust particles have the greater average concentrations of S and Cu ?

	greater Si and Fe	greater S and Cu
F.	larger dust particles	larger dust particles
G.	larger dust particles	smaller dust particles
H.	smaller dust particles	larger dust particles
J.	smaller dust particles	smaller dust particles

35. The total volume of air, in liters, that was drawn through the impactor each hour is given by which of the following expressions?

A. 1.1 L/min × 60 min
B. 1.1 L/min ÷ 60 min
C. 1.1 L/min × 1 hr
D. 1.1 L/min ÷ 1 hr

36. Days with no precipitation were most likely chosen as study days because precipitation would have:

F. caused dust particles in the air to condense.
G. caused dust particles in the air to vaporize.
H. removed dust particles from the air.
J. put more dust particles into the air.

37. What was the average mass of the < 0.25 μm dust particles that were collected by the impactor on the fair weather days?

A. 0.5 μg
B. 5 μg
C. 50 μg
D. Cannot be determined from the given information

38. For both the fair weather days and the dust storm days, why were the results for Si and Fe plotted on a different *y*-axis scale than were the results for S and Cu ?

F. In general, Si and Fe were present at much lesser concentrations in the particles than were S and Cu.
G. In general, Si and Fe were present at much greater concentrations in the particles than were S and Cu.
H. Particles containing Si and Fe belonged to smaller particle size ranges than did particles containing S and Cu.
J. Particles containing Si and Fe belonged to larger particle size ranges than did particles containing S and Cu.

39. The average concentrations of how many of the elements were generally greater for the dust storm days than for the fair weather days?

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

40. Based on the description of the design of the impactor, particles belonging to which size range were removed from the air by the first filter the air passed through?

F. < 0.25 μm
G. 0.50–1.0 μm
H. 2.0–4.0 μm
J. > 16.0 μm

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.