Chapter 4
Now Passages

Passage I

Reduction by carbon process, thermite process, and reduction by heating alone are different ways of converting a metal oxide to pure metal. Reactions 1–3 are examples of these processes using zinc oxide, manganese dioxide, and mercuric oxide, respectively.

Reaction 1: $ZnO + C \rightarrow Zn + CO$

Reaction 2: $3MnO_2 + 4Al \rightarrow 3Mn + 2Al_2O_3$

Reaction 3: $2HgO \xrightarrow{\text{heating}} 2Hg + O_2$

In each case, the resulting sample is composed of the metal and another product, which is filtered out to leave only the pure metal.

Figures 1–3 below show how *percent pure metal* (% PM) varied as a function of time in Reactions 1–3, respectively, both in the absence and the presence of a magnetic field.

$$\% \text{ PM} = \frac{\text{mass of pure metal}}{\text{mass of metal oxide} + \text{mass of pure metal}} \times 100$$

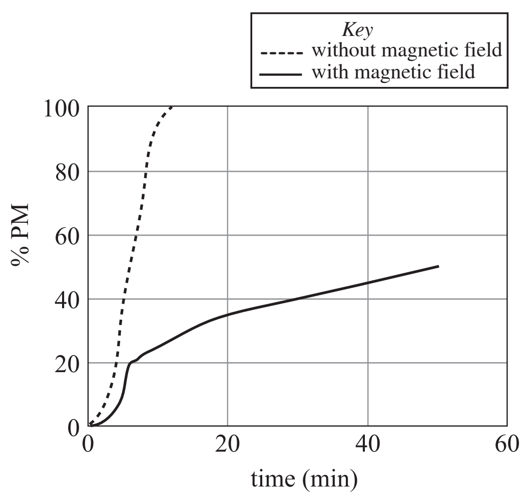


Figure 1

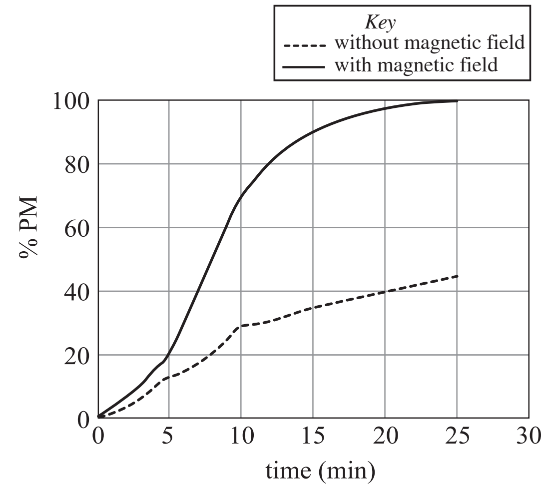


Figure 2

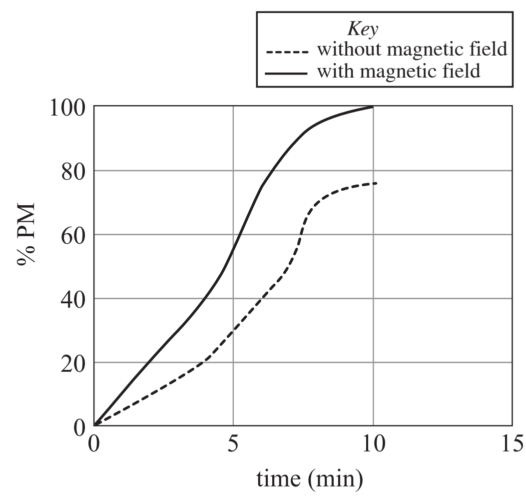


Figure 3

1. According to Figure 1, during Reaction 1 with a magnetic field, the % PM observed at 20 min was approximately:

A. 40%.
B. 35%.
C. 25%.
D. 20%.

2. Suppose that during Reaction 3 with a magnetic field, the magnetic field had been removed at time = 5 min. Three minutes later, at time = 8 min, the % PM would most likely have been:

F. greater than 60%.
G. between 40% and 60%.
H. between 20% and 40%.
J. less than 20%.

3. According to Figure 2, in Reaction 2, how did the absence of a magnetic field affect the yield of pure metal at time = 20 min? The yield obtained without a magnetic field was about:

A. $\frac{2}{5}$ the yield obtained with a magnetic field.

B. $\frac{4}{5}$ the yield obtained with a magnetic field.

C. $2\frac{1}{2}$ times that of the yield obtained with a magnetic field.

D. 3 times the yield obtained with a magnetic field.

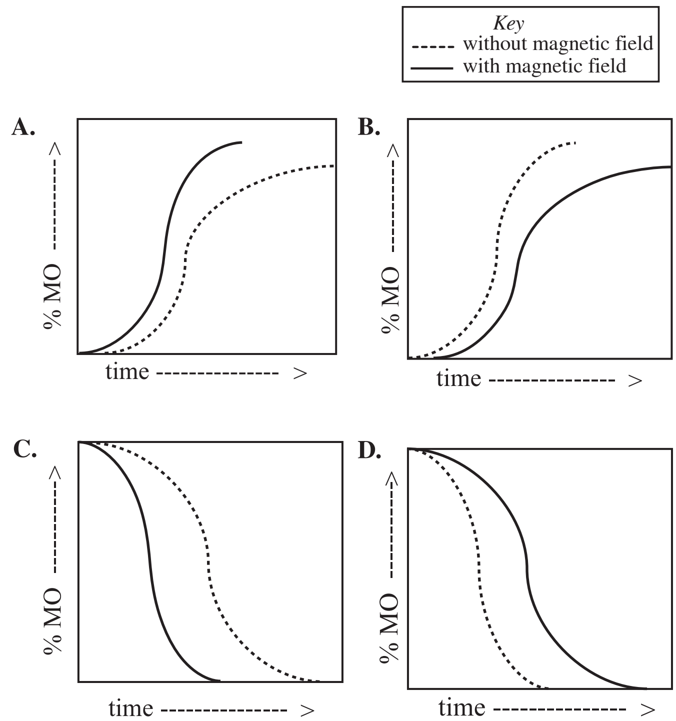
4. A chemist claimed that separating pure metal using a magnetic field is always faster than without a magnetic field. Do Figures 1–3 support this claim?

F. No; in Reaction 1 the % PM reached 0% sooner without a magnetic field than with a magnetic field.
G. No; in Reaction 1 the % PM reached 100% sooner without a magnetic field than with a magnetic field.
H. Yes; the % PM consistently reached 0% sooner with a magnetic field for all three reactions than without.
J. Yes; the % PM consistently reached 100% sooner with a magnetic field for all three reactions than without.

5. If Reaction 3 had been graphed as *percent of metal oxide* (% MO) as time increases instead of % PM:

$$\% \text{ MO} = \frac{\text{mass of metal oxide}}{\text{mass of metal oxide} + \text{mass of pure metal}} \times 100$$

Which of the following graphs best represents how Figure 3 would have appeared?



6. Suppose Reaction 2 and Reaction 3 were started at the same time in the presence of a magnetic field. Which metal, manganese or mercury, would reach 50% PM first, and how much faster would it be?

F. The manganese will reach 50% PM approximately 3.5 minutes before the mercury.
G. The mercury will reach 50% PM approximately 3.5 minutes before the manganese.
H. The manganese will reach 50% PM approximately 8 minutes before the mercury.
J. The mercury will reach 50% PM approximately 8 minutes before the manganese.

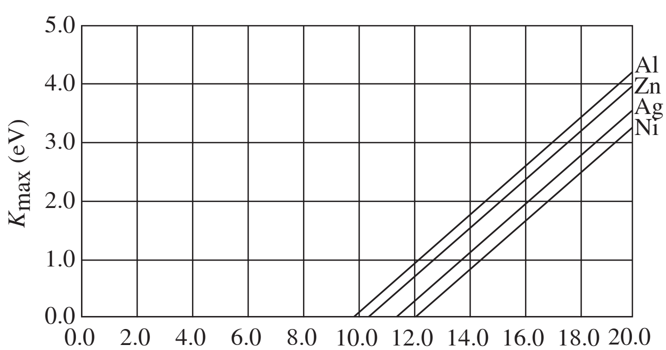
Passage II

When light strikes a metal surface, the energy of the photons is transferred to the metal surface and frees electrons from the metal in a process called the *photoelectric effect.* The energy required to free an electron differs depending on the type of metal and is called the *work function* of the metal. The energy contained within a photon can be determined by that photon's frequency. The *threshold frequency* for a metal, or f_T, is the minimum frequency at which the photon energy will be sufficient to free an electron. This is the frequency at which photon energy is equal to work function. If the frequency is higher than f_T, the extra energy may be given to the ejected electron. The maximum energy that may be transferred at each frequency is called K_{max}.

Table 1 shows the work functions in electron volts (eV) for aluminum, (Al), zinc (Zn), nickel (Ni), and silver (Ag). Figure 1 shows the K_{max} of each metal in relation to the frequency for each of the metals.

Table 1

Metal	Work function (eV)
Al	4.08
Zn	4.30
Ag	4.73
Ni	5.01



frequency (10^{14} Hz)
Figure 1

1. For a photon to free an electron from Zn, the photon's work function must be at least:

A. 4.23 eV.
B. 4.30 eV.
C. 4.61 eV.
D. 5.31 eV.

2. Based on Figure 1, which of the following correctly ranks Al, Ni, and Ag in order of increasing K_{max} at 15.0×10^{14} Hz ?

F. Al, Ag, Ni
G. Al, Ni, Ag
H. Ni, Ag, Al
J. Ni, Al, Ag

3. Based on Table 1 and Figure 1, as frequency increases, K_{max}:

A. decreases.
B. increases.
C. increases, then decreases.
D. decreases, then increases.

4. Based on Figure 1, for electrons ejected from Al by photons with frequency = 26.0×10^{14} Hz, K_{max} would be:

F. greater than 5.0 eV.
G. between 4.5 eV and 5.0 eV.
H. between 4.0 eV and 4.5 eV.
J. less than 4.0 eV.

5. Photons having frequencies of 12.0×10^{14} Hz and 18.0×10^{14} Hz strike a new metal, Metal Q, resulting in freed electrons with the following K_{max}:

Photon frequency (10^{14} Hz)	K_{max} (eV)
12.0	0.5 eV
18.0	3.0 eV

Based on Table 1 and Figure 1, the work function of Metal Q is most likely closest to which of the following?

A. 4.01 eV
B. 4.20 eV
C. 4.28 eV
D. 4.51 eV

6. Based on Figure 1, the threshold frequency of Ag is approximately:

F. 3.5×10^{14} Hz.
G. 11.5×10^{14} Hz.
H. 16.0×10^{14} Hz.
J. 20.0×10^{14} Hz.

Passage III

Scientists studied the effects of Drug X on various strains of bacteria in the *Staphylococcus* genus. Table 1 shows the bacteria that were tested and the ED_{50} (the dosage necessary to achieve a therapeutic effect for 50% of the population that is given the medication) of each bacterial strain.

Table 1

Bacterium	Species	ED_{50} of Drug X (mg/L)
A	*Staphylococcus aureus*	15.3
B	*Staphylococcus carnosus*	30.6
C	*Staphylococcus gallinarum*	22.7
D	*Staphylococcus vitulinus*	91.3
E	*Staphylococcus warneri*	62.6

Six flasks containing 500 mL of nutrient broth were prepared, each with 10,000 cells of *Staphylococcus aureus*. Drug X was then added to five of the flasks in different concentrations, and all six flasks were incubated at 37ºC for 24 hours. This procedure was then repeated for the four other bacterial strains. Figure 1 shows the percentage of cells killed for each bacterial strain at each concentration of Drug X.

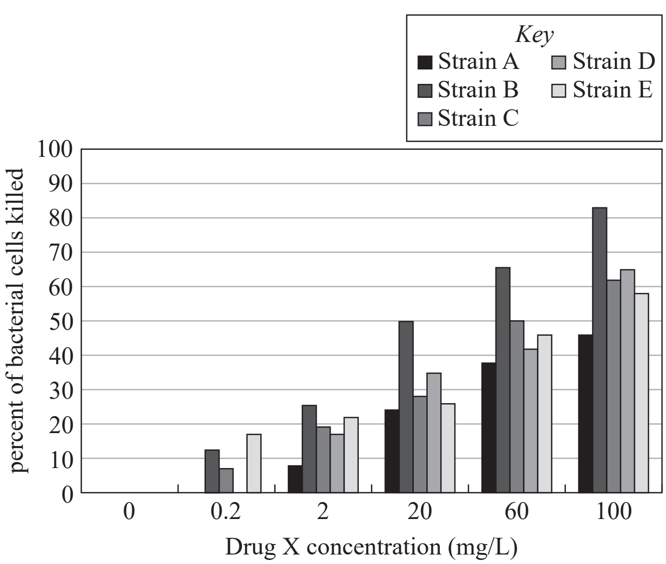


Figure 1

1. According to Figure 1, as the concentration of Drug X increased, the percent of bacterial cells killed from Strain C:

   A. increased, then remained the same.
   B. decreased, then remained the same.
   C. increased only.
   D. decreased only.

2. Based on Table 1, which strain of bacterium requires the highest concentration of Drug X to achieve a therapeutic effect for 50% of the population that is given the medication?

   F. Strain A
   G. Strain B
   H. Strain D
   J. Strain E

3. Based on Figure 1, if cells from Strain B had been treated with Drug X at a concentration of 200 mg/L, the percent of bacterial cells killed would most likely have been:

   A. less than 75%.
   B. between 75% and 80%.
   C. between 80% and 85%.
   D. greater than 85%.

4. According to Table 1, the concentration of Drug X necessary to achieve a therapeutic effect for 50% of the population from Strain E was approximately 4 times the concentration of Drug X necessary to achieve a therapeutic effect for 50% of the population from:

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

5. According to Figure 1, which of the following actions leads to the largest increase in the number of Strain E bacterial cells killed by Drug X ?

   A. Increasing the concentration of Drug X from 0 mg/L to 0.2 mg/L
   B. Increasing the concentration of Drug X from 2 mg/L to 20 mg/L
   C. Increasing the concentration of Drug X from 20 mg/L to 60 mg/L
   D. Increasing the concentration of Drug X from 60 mg/L to 100 mg/L

6. A researcher hypothesized that the strain with the lowest therapeutic dose will have more cells killed than any of the other strains at all dosages of Drug X under 30 mg/L. Is this hypothesis supported by the data in Table 1 and Figure 1 ?

   F. Yes; Strain A has the least percentage of bacteria killed at dosages of 0.2, 2, and 20 mg/L.
   G. Yes; Strain B has the least percentage of bacteria killed at dosages of 2 and 20 mg/L.
   H. No; Strain A has the greatest percentage of bacteria killed at dosages of 0.2, 2, and 20 mg/L.
   J. No; Strain B has the greatest percentage of bacteria killed at dosages of 2 and 20 mg/L.

Passage IV

A *resistor* is an object that creates electrical resistance in a circuit.

R is the electrical resistance, in *ohms* (Ω), which describes the tendency of a resistor to oppose electric conduction. Conductance, *G*, in siemens (S), is the inverse of *R*: it describes the tendency of a resistor to allow electric conduction. When a voltage, *V*, in volts (V), is run across a circuit, *R* will affect the resulting current, *I*, measured in amperes (A).

Students tested several different resistors. For each trial, the students applied a series of voltages across a circuit that contained a resistor and measured the resulting current. The students then calculated the power, *P*, in watts (W), delivered through the circuit. *P* is a measure of the rate at which current flows across a circuit.

Study 1

In Trials 1–5, the circuit contained a blue resistor with $R = 0.005$ Ω. The results are shown in Table 1. Each trial had a different voltage (*V*) across the circuit.

Table 1

Trial	*V* (V)	*I* (A)	*P* (W)
1	0.02	4	0.08
2	0.04	8	0.32
3	0.06	12	0.72
4	0.08	16	1.28
5	0.09	18	1.62

Study 2

In Trials 6–10, the circuit contained a red resistor with $R = 0.015$. As in Study 1, each trial had a different voltage (*V*) across the circuit.

Table 2

Trial	*V* (V)	*I* (A)	*P* (W)
6	0.02	1.3	0.03
7	0.04	2.7	0.11
8	0.06	4	0.24
9	0.08	5.3	0.43
10	0.09	6	0.54

Study 3

In Trials 11–15, the circuit contained a green resistor with $R = 0.04$ Ω. As in the prior studies, each trial had a different voltage (*V*) across the circuit.

Table 3

Trial	*V* (V)	*I* (A)	*P* (W)
11	0.02	0.5	0.01
12	0.04	1	0.04
13	0.06	1.5	0.09
14	0.08	2	0.16
15	0.09	2.2	0.20

1. If an additional trial had been conducted in Study 1 with $V = 0.03$ V, the value of *P* for this additional trial would most likely have been:

A. less than 0.08 watts.
B. between 0.08 watts and 0.32 watts.
C. between 0.32 watts and 0.72 watts.
D. greater than 1.62 watts.

2. In each study, as the voltage across each circuit increased, the electrical power:

F. remained the same.
G. varied, but with no general trend.
H. decreased only.
J. increased only.

3. The students then tested two new circuits, Circuit A (with Resistor A) and Circuit B (with Resistor B). The students ran the same voltage across each of the new circuits. Circuit A exhibited a higher electrical power compared to Circuit B. Based on Studies 1–3, which resistor has the higher electrical resistance?

A. Resistor A, because a higher resistance results in a lower power.
B. Resistor A, because a lower resistance results in a lower power.
C. Resistor B, because a higher resistance results in a lower power.
D. Resistor B, because a lower resistance results in a lower power.

4. In which of the following trials was the *conductance* (*G*) of the circuit the greatest?

F. Trial 1
G. Trial 6
H. Trial 11
J. Trials 1, 6, and 11 all have the same conductance.

5. Prior to the studies, 4 students made predictions about which of the 3 resistors, if any, would have the lowest *P* for a given *V*. Student L predicted that it would be the blue resistor. Student M predicted that it would be the red resistor. Student N predicted that it would be the green resistor, and Student O predicted that all three resistors would have the same *P* for a given *V*. Which prediction is correct?

A. Student L
B. Student M
C. Student N
D. Student O

6. A student concluded that, for a constant resistance, increasing the value of *V* by a factor of 3 increases the value of *P* by a factor of 9. Which pair of trials best supports this conclusion?

F. 1 and 8
G. 2 and 4
H. 6 and 13
J. 11 and 13

7. A fourth resistor, the purple resistor, has a current of 3 A at a voltage of 0.06 V. The resistance of the purple resistor is most likely:

A. less than 0.005 ohms.
B. between 0.005 and 0.015 ohms.
C. between 0.015 and 0.04 ohms.
D. greater than 0.04 ohms.

Passage V

In 3 studies, students investigated the thermal expansion of rectangular metal rods various lengths and materials (see Figure 1).

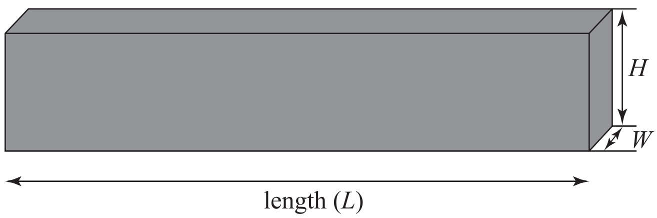


Figure 1

Using the water bath shown in Figure 2, the students heated the rods to different temperatures.

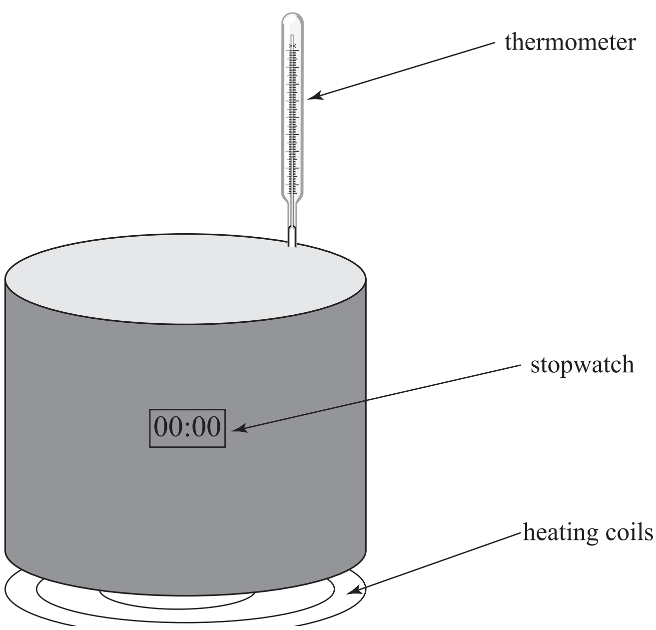


Figure 2

In each trial, the rod was transferred to a water bath preheated to a particular temperature and then allowed to incubate for a set amount of time. During the incubation process, water temperature was kept constant while the metal rods underwent thermal expansion.

After completion of the incubation, the metal rod was removed, and the length, width, and height of the metal rod were promptly measured. After being measured, the metal rod returned to room temperature and reverted to its original dimensions.

The intrinsic thermal expansion of the metal rod was represented by the *volumetric expansion constant*, β.

Study 1

In Trials 1–4, students determined the change in volume, ΔV, for rods of different lengths, L (see Table 1). In every trial, the time of incubation was 30 minutes and the temperature was 80°C.

Table 1

Trial	L (mm)	ΔV (mm^3)
1	50	1.5
2	100	3.1
3	150	4.5
4	200	5.9

Study 2

In Trials 5–8, students determined ΔV for rods of the same L composed of Metals W–Z, respectively. Each metal had a different value of β (see Table 2). In every trial, L = 100 mm, the time of incubation was 30 minutes, and the temperature was 80°C.

Table 2

Trial	Metal	β (°C^{-1})	ΔV (mm^3)
5	W	0.8	1.7
6	X	1.4	3.1
7	Y	2.2	4.9
8	Z	4.6	10.2

Study 3

In Trials 9–12, students determined ΔV for rods at different temperatures (see Table 3). In every trial, L = 100 mm, and the incubation time was 30 minutes.

Table 3

Trial	Temperature (C°)	ΔV (mm^3)
9	40	5.1
10	60	7.7
11	80	10.2
12	100	12.8

1. If density is defined as mass divided by volume, which of the following is true concerning the change in density of the metal beam after incubation in the water bath?

A. Density increases because the volume increases.
B. Density decreases because the volume decreases.
C. Density increases because the mass increases.
D. Density decreases because the volume increases.

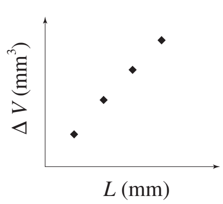
2. If, in Study 3, a trial had been conducted in which the incubation temperature was 70°C, ΔV would most likely have been closest to which of the following?

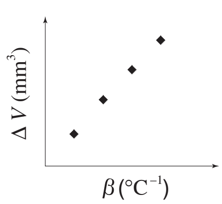
F. 6.5 mm^3
G. 7.2 mm^3
H. 8.9 mm^3
J. 10.4 mm^3

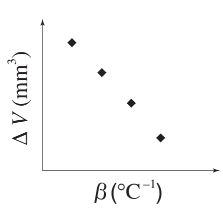
3. If the thermal energy contained within the metal rod is proportional to the product of the incubation time and the initial length, in which of the following trials does the rod contain the greatest amount of thermal energy following incubation?

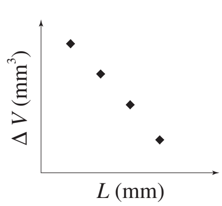
A. Trial 2
B. Trial 4
C. Trial 10
D. Trial 12

4. The results of Study 1 are best represented by which of the following graphs?

F.


G.


H.


J.


5. The beam tested in Study 3 was most likely composed of which of the metals tested in Study 2 ?

A. Metal Z
B. Metal Y
C. Metal X
D. Metal W

6. Based on the results of Studies 1 and 2, for a given temperature, which of the following combinations of L and β would yield the greatest thermal expansion?

	L (mm)	β (°C^{-1})
F.	100	4.6
G.	100	2.2
H.	200	4.6
J.	200	2.2

7. In a new study, Study 4, the conditions of Study 2 were replicated except that the bars used in Study 4 were 20% wider than those used in Study 2. Based on the information in Study 1 and Study 2, how would the values of β and ΔV in Trials 13–16 of Study 4 compare to those in Trials 5–8, respectively?

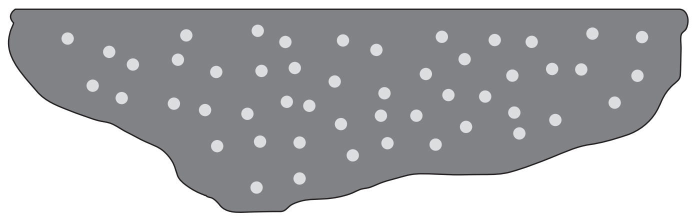
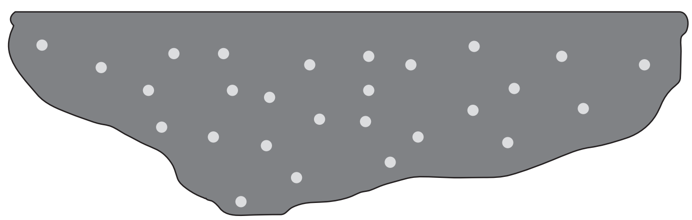
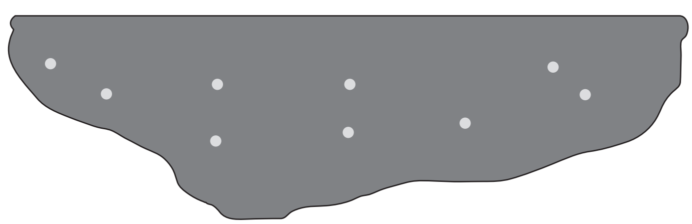
A. In Trials 13–16, the values of β would be greater than those in Trials 5–8, and the values of ΔV would be the same as those in Trials 5–8.
B. In Trials 13–16, the values of β would be the same as those in Trials 5–8, and the values of ΔV would be greater than those in Trials 5–8.
C. In Trials 13–16, the values of β and ΔV would be the same as those in Trials 5–8.
D. In Trials 13–16, the values of β and ΔV would be greater than those in Trials 5–8.

Passage VI

The pesticides *propargyl bromide* (PBr) and *1,3-dichloropropene* (1,3-D) are removed from the soil by a variety of factors, including uptake by plants, adsorption by soil, and breakdown by microorganisms, such as those found in manure. Also, PBr can degrade into *propargyl alcohol.*

Three pairs of pesticide-free soil samples were collected for a study: heavily manure-amended (H1, H2), slightly manure-amended (S1, S2), and unamended (U1, U2), as described in Table 1. On day 1, PBr was added to H1, S1, and U1 and 1,3-D was added to H2, S2, and U2 to produce an initial pesticide concentration of 500 mg/L in each soil sample. PBr, propargyl alcohol, and 1,3-D concentrations in the soil were measured at intervals over the next 12 weeks (see Figures 1–3).

Table 1

Soil	Description of soil
Heavily manure-amended (H1, H2)	 Abundant composted steer manure throughout the soil
Slightly manure-amended (S1, S2)	 Limited composted steer manure throughout the soil
Unamended (U1, U2)	 No composted steer manure throughout the soil

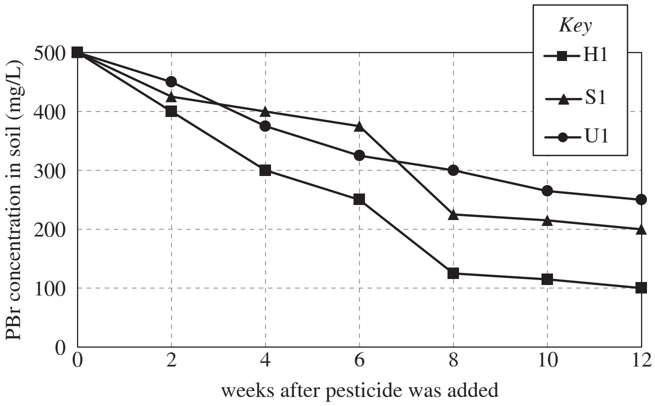


Figure 1

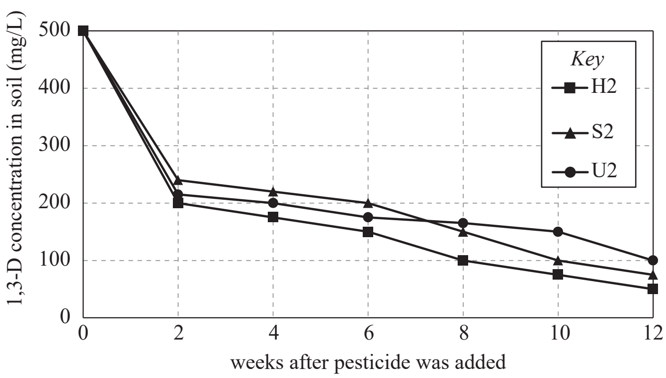


Figure 2

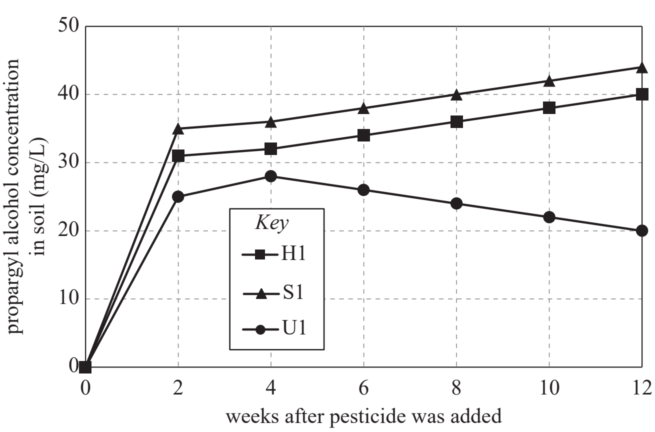


Figure 3

1. Assume that the environmental factors (ultraviolet radiation, wind drift, temperature, and moisture) for each soil sample remained constant over the 12 weeks of the study. According to Figure 2, 12 weeks after 1,3-D was added, what percent of the original 1,3-D concentration remained in the soil in U2 ?

A. Less than 10%
B. Between 10% and 30%
C. Between 30% and 50%
D. Greater than 50%

2. According to Figure 1, 5 weeks after PBr was added, the concentration in the soil in S1 compared to its concentration in H1 was about:

F. 112 mg/L lower.
G. 112 mg/L higher.
H. 275 mg/L lower.
J. 275 mg/L higher.

3. According to Figures 1 and 3, as the PBr concentration in S1 decreased, the propargyl alcohol concentration:

A. decreased only.
B. decreased, then increased.
C. increased only.
D. increased, then decreased.

4. Is the statement "Over the 12 weeks of the study, PBr concentration was most reduced in the unamended soil sample" supported by the data in Figure 1 ?

F. Yes; 12 weeks after PBr was added, its concentration was least in U1.
G. Yes; 12 weeks after PBr was added, its concentration was least in H1.
H. No; 12 weeks after PBr was added, its concentration was least in U1.
J. No; 12 weeks after PBr was added, its concentration was least in H1.

5. As shown in Figure 2, every time the 1,3-D concentrations in the soil in H2, S2, and U2 were measured during the study, the concentrations in S2 and H2 were found to be very similar to the concentration in U2. The most likely explanation for this is that in S2 and H2:

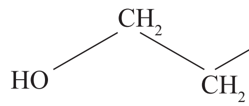
A. adsorption onto soil particles and plant uptake played a more significant role in removing 1,3-D than did breakdown to form PBr.
B. adsorption onto soil particles and plant uptake played a less significant role in removing 1,3-D than did breakdown to form PBr.
C. bacterial decomposition played a more significant role in removing 1,3-D than did adsorption onto soil particles and plant uptake.
D. bacterial decomposition played a less significant role in removing 1,3-D than did adsorption onto soil particles and plant uptake.

6. After two weeks, in which soil was the concentration of PBr reduced the least and in which soil was the concentration of 1,3-D reduced the least?

	PBr	1,3-D
F.	U1	S2
G.	H1	H2
H.	U1	U2
J.	S1	U2

Passage VII

Ethylene glycol is the main ingredient in antifreeze and has the chemical structure shown below:



Figures 1–3 show how solutions of antifreeze vary as the concentration of ethylene glycol changes. Concentration is given as the percent ethylene glycol by volume in water (% EG) at atmospheric pressure (101.3 kPa). Figure 1 shows how the melting point (the temperature at which a solid would begin melting) of antifreeze varies with % EG. Figure 2 shows how the boiling point of antifreeze varies with % EG. Figure 3 shows how the density at 25°C varies with % EG.

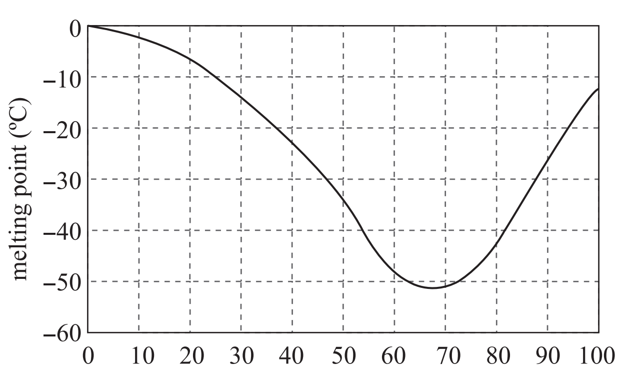


Figure 1

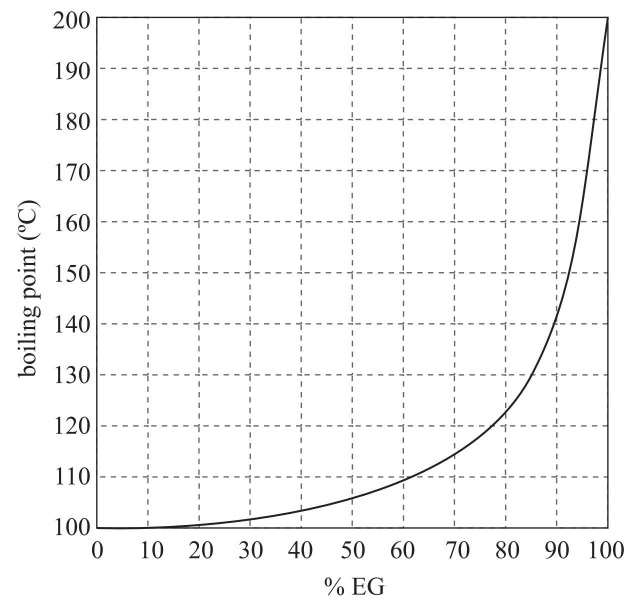


Figure 2

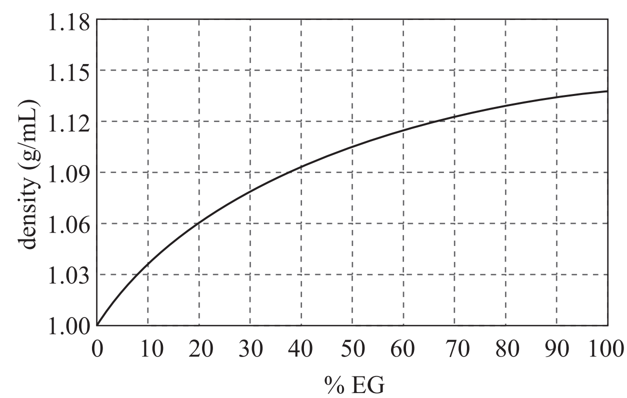


Figure 3

1. At 101.3 kPa, which of the following solutions will have the *lowest* freezing point?

A. 100% EG
B. 68% EG
C. 33% EG
D. 0% EG

2. According to Figure 1, the temperature at which solid antifreeze begins to melt in a 60% EG solution at 101.3 kPa is closest to which of the following?

F. 0°C
G. –12°C
H. –48°C
J. –60°C

3. Based on Figure 2, which of the following solutions has a boiling point equal to pure water at 101.3 kPa?

A. 0% EG
B. 13% EG
C. 68% EG
D. 100% EG

4. At 25°C, as the % EG increases from 0% to 100%, the mass per unit volume:

F. increases only.
G. decreases only.
H. increases, then decreases.
J. decreases, then increases.

5. According to Figures 2 and 3, a solution of antifreeze that has a density of 1.09 g/mL at 25°C will have a boiling point closest to which of the following?

A. 100°C
B. 104°C
C. 111°C
D. 122°C

6. Based on the information in the passage, what is the chemical formula for ethylene glycol?

F. $C_2H_6O_2$
G. $C_6H_6O_2$
H. $C_2H_4O_2$
J. C_2H_2O

Passage VIII

In 1789, Mt. Mantu erupted off the coast of Brunei releasing a cloud of ash that lowered global temperatures for 15 years. When a volcano erupts, it releases a cloud of ash, dust, and debris into the atmosphere thousands of times the volume of the volcano. In addition, at the time of the eruption, the volcano produces a mud and ash flow along the sides of the volcano. The ash flow around Mt. Mantu covered an area 30 times larger than the original size of the volcano. Figure 1 shows the volume of the ash clouds released by volcanoes of differing diameters during the last 200 million years.

Figure 2 shows the average amount of time elapsed between consecutive major eruptions of various volcanoes of similar sizes, for a range of volcano sizes. Figure 3 shows the number of major volcanic eruptions of various volcanic ash flow diameters over the past 1,000 years for three different mountain ranges.

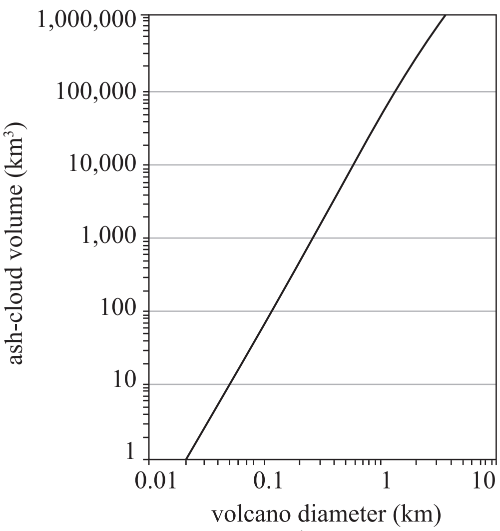


Figure 1

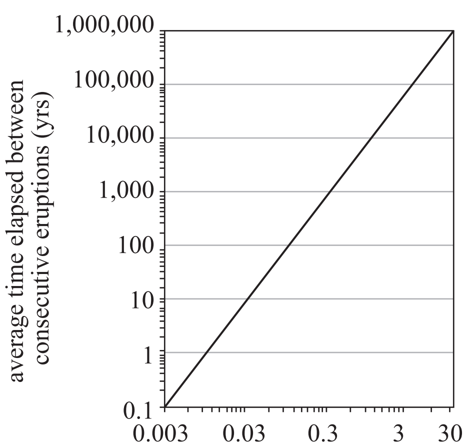


Figure 2

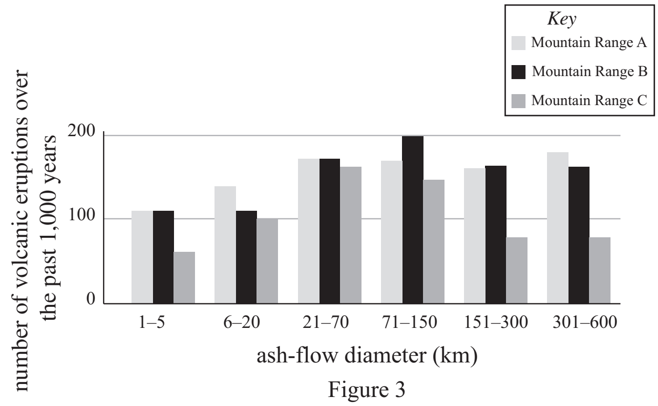


Figure 3

1. If 100 km^3 of ash was released by Mt. Mantu, according to Figure 1, Mt. Mantu's diameter was most likely closest to which of the following?

   A. 0.02 km
   B. 0.01 km
   C. 0.1 km
   D. 1 km

2. According to Figure 2, as the volcano diameter increases, the average amount of time between consecutive eruptions:

   F. increases only.
   G. decreases only.
   H. varies, but with no general trend.
   J. remains the same.

3. According to Figure 3, for any given range of volcanic ash flows, the number of eruptions within the past 1,000 years in Mountain Range C is:

   A. less than the number in either Mountain Range A or Mountain Range B.
   B. less than the number in Mountain Range A, but greater than the number in Mountain Range B.
   C. greater than the number in either Mountain Range A or Mountain Range B.
   D. greater than the number in Mountain Range A, but less than the number in Mountain Range B.

4. Suppose a volcano similar to Mt. Mantu created an ash flow that was 30 km in diameter. Based on Figure 1 and other information provided, that volcano would have released a volume of ash closest to which of the following?

F. 5,000 km^3
G. 10,000 km^3
H. 50,000 km^3
J. 100,000 km^3

5. Assume that a volcano with a diameter of 30 km erupted 500,000 years ago. If the time that elapses between eruptions is equal to the average amount of time given in Figure 2, the volcano should erupt approximately:

A. 250,000 years from now.
B. 500,000 years from now.
C. 1,000,000 years from now.
D. 1,500,000 years from now.

6. Mt. Vesuvius has a crater at the summit of the volcano that is over 6 km wide. A geologist reports that Mt. Vesuvius has experienced 8 major eruptions in the past 17,000 years. Is the eruption history of Mt. Vesuvius consistent with the information in Figure 2 ?

F. Yes; Mt. Vesuvius erupts at a rate similar to the rate depicted in Figure 2 for a volcano of similar size.
G. Yes; Mt. Vesuvius erupts more frequently than the rate depicted in Figure 2 for a volcano of similar size.
H. No; Mt. Vesuvius erupts less frequently than the rate depicted in Figure 2 for a volcano of similar size.
J. No; Mt. Vesuvius erupts more frequently than the rate depicted in Figure 2 for a volcano of a similar size.

Passage IX

Electromagnets are used in a variety of industrial processes and often consist of a large *solenoid*, a helical coil of wire, that produces a uniform *magnetic field strength* when a current passes through it (see Figure 1).

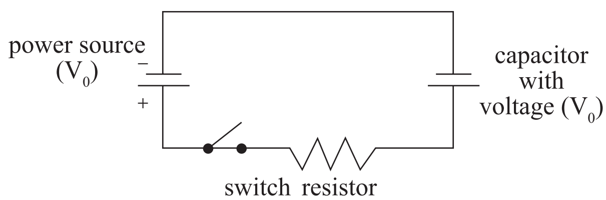


Figure 1

The magnetic field of a solenoid is a factor of its resistance to changes in current, a property called *inductance* (*L*). The *relative permeability*, μ, is a property of the material within the solenoid coils which may magnify the magnetic field strength.

Figure 2 shows how magnetic field strength varies with the number of coils (*N*) at different currents (*I*) when the length and cross-sectional area of the solenoid is held constant.

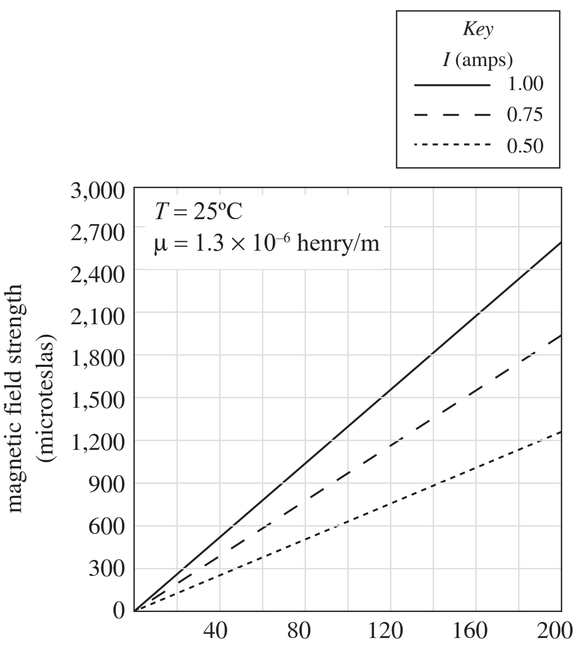


Figure 2

Figure 3 shows, for specific values of *A* (cross-sectional area of the solenoid) and *N*, how *L* varies with solenoid length at 25°C.

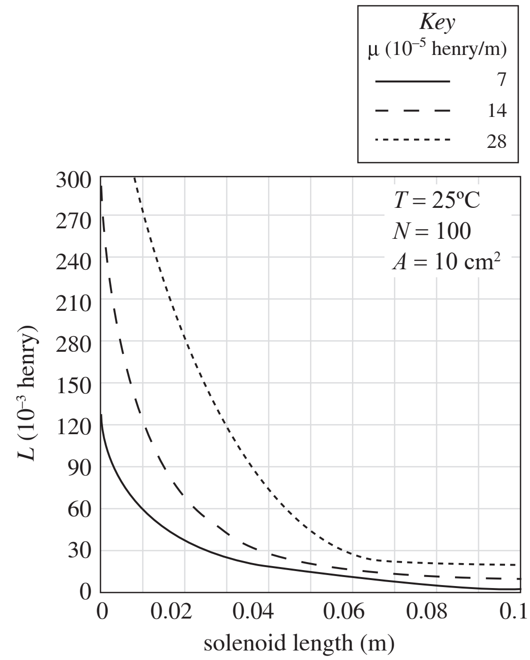


Figure 3

1. For the conditions specified in Figure 2 and $I = 0.75$ amps, the solenoid will attract iron metal particles most strongly when the number of coils is closest to which of the following?

A. 0 coils
B. 40 coils
C. 120 coils
D. 200 coils

2. According to Figure 2, does magnetic field strength vary with current?

F. Yes; As current decreases, magnetic field strength increases.
G. Yes; As current increases, magnetic field strength increases.
H. No; As current decreases, magnetic field strength increases.
J. No; As current remains the same, magnetic field strength increases.

3. According to Figure 3, for $\mu = 14 \times 10^{-5}$ henry/m, as the length of the solenoid increases, *L*:

A. increases only.
B. decreases only.
C. varies, but with no consistent trend.
D. remains the same.

4. For a given solenoid length, what is the correct ranking of the values of μ in Figure 3, from the μ associated with the highest *L* to the μ associated with the lowest *L* ?

F. 7×10^{-5} henry/m, 14×10^{-5} henry/m, 28×10^{-5} henry/m
G. 14×10^{-5} henry/m, 28×10^{-5} henry/m, 7×10^{-5} henry/m
H. 7×10^{-5} henry/m, 28×10^{-5} henry/m, 14×10^{-5} henry/m
J. 28×10^{-5} henry/m, 14×10^{-5} henry/m, 7×10^{-5} henry/m

5. Based on Figure 2, a solenoid containing 100 coils with a magnetic field strength of 300 would most likely have been produced by a current:

A. greater than 1.00 amps.
B. between 1.00 and 0.75 amps.
C. between 0.75 and .50 amps.
D. less than 0.50 amps.

6. Assuming all other conditions are held constant, which of the following pairs of solenoid length and μ values would have the highest inductance?

	Length (m)	μ (henry/m)
F.	0.02	5×10^{-5}
G.	0.03	5×10^{-5}
H.	0.02	9×10^{-5}
J.	0.03	9×10^{-5}