

Question Source:

NYSTCE (New York) Chemistry Sample Test

Use the information below to answer the question that follows.

The chemical composition of a mineral is variable within a narrow range of possibilities. This is because ions of equal charge and similar size can substitute for one another. Coupled substitutions are also possible. In a coupled substitution, ions of different charges substitute for one another. When this happens, a second substitution must also occur to compensate for the unbalanced charge that results from the first substitution. For instance, the ion pair $\text{Na}^{+1}\text{Al}^{+3}$ can substitute for the ion pair $\text{Ca}^{+2}\text{Mg}^{+2}$.

A common formula of the mineral plagioclase is $\text{NaAlSi}_3\text{O}_8$. Which of the following chemical formulas represents plagioclase in which the ion pair $\text{Ca}^{+2}\text{Al}^{+3}$ substitutes for the ion pair $\text{Na}^{+1}\text{Si}^{+4}$?

- A. Ca_2AlO_8
- B. $\text{Ca}_2\text{Al}_2\text{SiO}_8$
- C. CaAlO_8
- D. $\text{CaAl}_2\text{Si}_2\text{O}_8$

Correct Response: D. The ion pair to be replaced has a +5 charge, as does the ion pair that is to be added. Since the overall charge on the formula for an ionic compound must be zero, these ion pairs can be substituted for each other in a 1:1 ratio. If one $\text{Na}^{+1}\text{Si}^{+4}$ ion pair is removed from the original plagioclase formula and replaced with one $\text{Ca}^{+2}\text{Al}^{+3}$ ion pair, the formula $\text{CaAl}_2\text{Si}_2\text{O}_8$ results.

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In the 1970s, environmentalists and the public became increasingly concerned about the consequences of depletion of Earth's ozone layer. This concern helped prompt an increase in research related to:

- A. battery technology.
- B. biodegradable plastics.
- C. aerosol propellants.
- D. lead-free gasoline.

Correct Response: C. In the mid-1970s, scientists first theorized that a group of atmospheric pollutants known as chlorofluorocarbons (CFCs) may be responsible for the observed depletion of Earth's ozone layer. These compounds were manufactured for many uses, including as propellants in aerosol spray cans. This connection prompted research into the impact of the CFCs from spray cans on the ozone layer, which ultimately led to bans on the use of CFCs by many countries.

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A scientist has recently discovered the mechanism by which an important biological reaction takes place. Which of the following subsequent steps is most likely to lead to broad acceptance of this discovery by the scientific community?

- A. The hypothesis that led to the discovery is announced and reported in a scientific journal.
- B. The experiment on which the new discovery is based is independently replicated in another laboratory.
- C. Previous hypotheses concerning the mechanism are tested and shown to be incapable of explaining existing data and observations.
- D. A majority of researchers working on this reaction or on similar reactions think that the conclusions of the scientist are reasonable.

Correct Response: B. All of the steps listed would aid, to some degree, in the broad acceptance of the discovery by the scientific community. The replication of experimental data by unbiased investigators, however, represents an important milestone in the discovery process. Of the choices listed, therefore, the independent replication of the experiment by another laboratory is the most important step towards broad acceptance by the scientific community.

Question Source:

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Use the formula below to answer the question that follows.

$$\log P = \frac{-\Delta H_v}{2.3RT} + C$$

The relationship between vapor pressure and temperature is described by this formula, where P represents vapor pressure, ΔH_v represents enthalpy of vaporization, T represents temperature, and R , C , and ΔH_v are constants. In order to represent this relationship as a straight line, the axes of the graph should represent:

- A. $\log P$ and T .
- B. $\log P$ and $1/T$.
- C. P and T .
- D. P and $1/T$.

Correct Response: B. If the given equation is written in the following form:

$$\log P = \frac{-\Delta H_v}{2.3R} \cdot \frac{1}{T} + C$$

it follows the mathematical representation for a straight line as $y = mx + b$. The slope (m) and the y -intercept (b) should be constants, and the values $-\Delta H_v$, R , and C are identified as constants in the question. The y -axis and x -axis of the graph should therefore represent $\log P$ and $\frac{1}{T}$, respectively.

Question Source:

NYSTCE (New York) Chemistry Sample Test

A student who is performing an experiment must measure out 0.02 mL of 0.50 M HCl. The most accurate piece of equipment to measure this quantity would be a:

- A. 50 mL buret.
- B. 25 mL graduated cylinder.
- C. 10 mL beaker.
- D. 1 mL pipet.

Correct Response: D. All of the pieces of equipment listed can be used to measure the volume of an aqueous solution. The laboratory equipment used for this task, however, would need gradations sufficiently small to measure accurately the relatively small volume of 0.02 mL. The 1 mL pipet would likely have a gradation every 0.01 mL and would, therefore, be the best choice for accurately measuring a volume of 0.02 mL.

Question Source:

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Use the information below to answer the question that follows.

REACTIVITY DATA

Stability:	stable
Hazardous Polymerization:	will not occur
Conditions to Avoid:	heat, flame, other sources of ignition, moisture
Incompatibles:	alkali metals, strong oxidizing agents, strong bases, oxides of nitrogen, zinc, aluminum, water, magnesium, amines
Decomposition Products:	hydrogen chloride, phosgene, carbon monoxide, carbon dioxide

The information above is excerpted from a material safety data sheet (MSDS) for methylene chloride. According to this data sheet, a hazard could be caused by allowing methylene chloride to come in contact with:

- A. sodium.
- B. calcium.
- C. hydrogen chloride.
- D. acetic acid.

Correct Response: A. A hazardous condition can occur when a substance comes in contact with another substance with which it is incompatible. The information from the MSDS identifies methylene chloride as incompatible with alkali metals, which are the elements in the first column of the periodic table. Therefore, a hazardous condition could arise if methylene chloride came in contact with sodium, an alkali metal.

Question Source:

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Which of the following methods provides information about a substance's chemical properties?

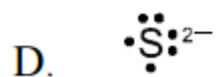
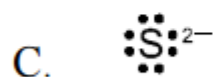
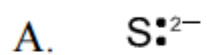
- A. acid-base titration
- B. X-ray diffraction
- C. fractional distillation
- D. mass spectrometry

Correct Response: A. A chemical property is a characteristic of a substance that is displayed as it undergoes a change in chemical composition. Only the acid-base titration involves the substance in a chemical reaction, and therefore a change in its chemical composition. The other methods mentioned provide information about a substance's physical properties.

Question Source:

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Which of the following shows the correct Lewis electron dot representation for a sulfur ion with a negative two charge?

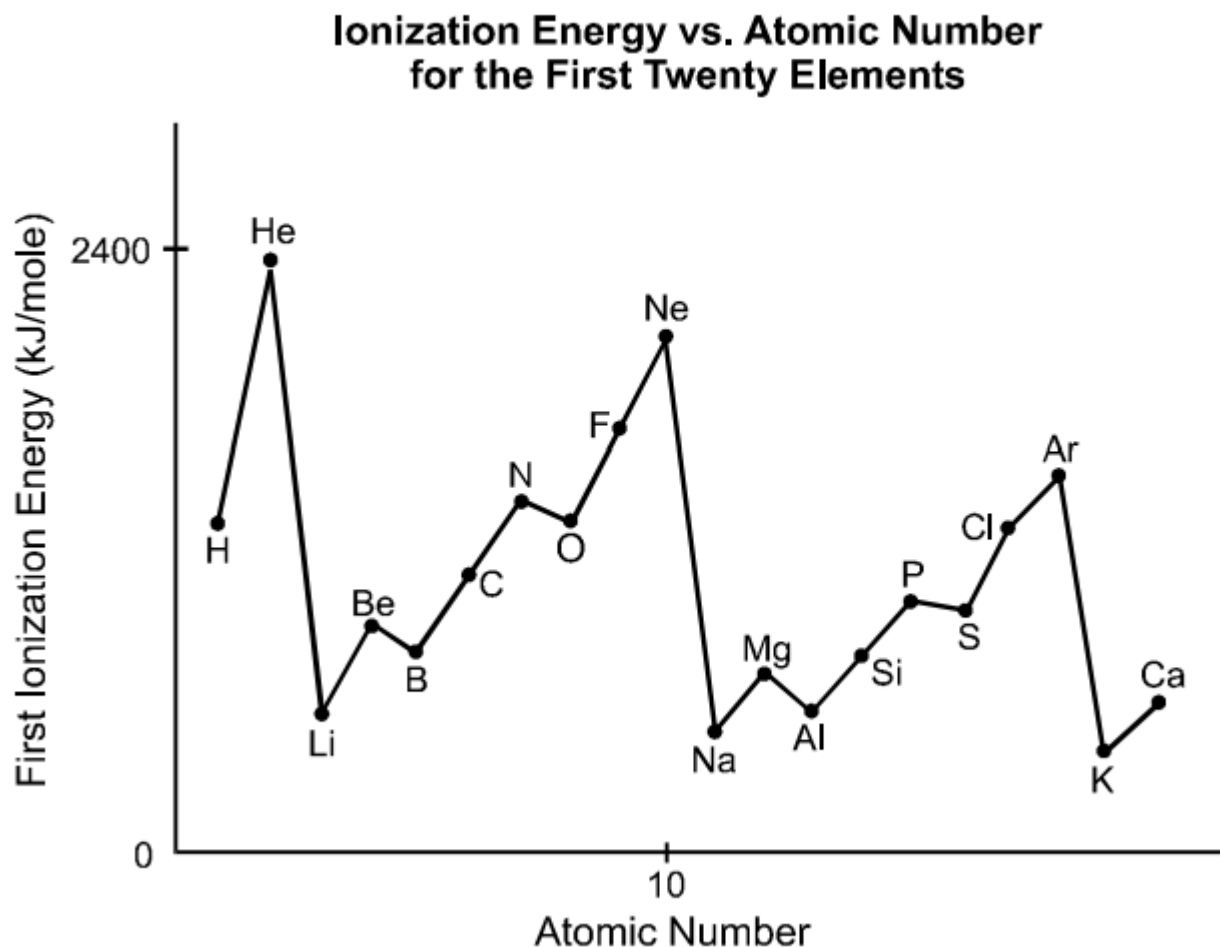


Correct Response: C. The Lewis electron dot representation for an atom or ion should show the particle with the correct number of valence electrons and charge. Based on its position in the periodic table (group 16), the neutral sulfur atom has six valence electrons. An ion with a -2 charge has two more electrons than the neutral atom. The sulfur ion with a -2 charge has eight valence electrons, and therefore should have eight dots in its Lewis structure.

Question Source:

NYSTCE (New York) Chemistry Sample Test

Use the diagram below to answer the question that follows.



The graph of first ionization energy plotted against atomic number shows that ionization energy is a periodic function. First ionization energy generally increases from alkali metals to noble gases. Exceptions to this general trend can be seen in going from beryllium to boron and from magnesium to aluminum. These two deviations from the line can best be explained by considering each element's:

- A. atomic radius.
- B. electron configuration.
- C. nuclear binding energy.
- D. atomic mass.

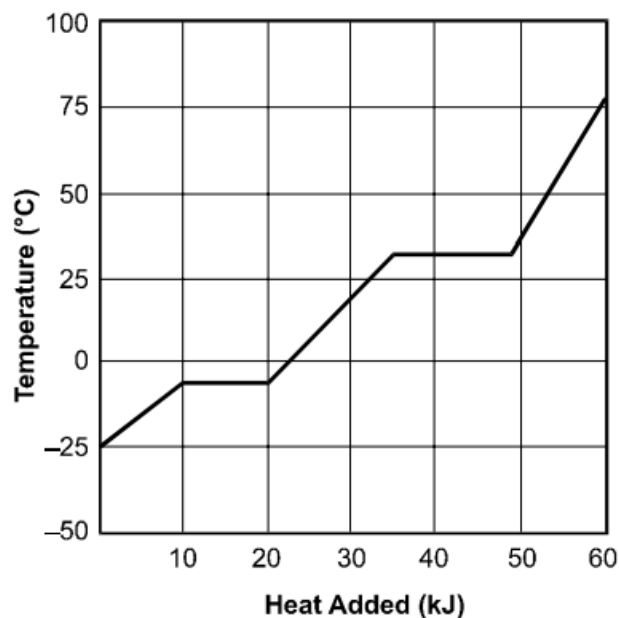
Correct Response: B. The first ionization energy is the energy required to remove the first electron from an atom in its ground state. In the Group 2 (IIA) elements, which include beryllium and magnesium, the electrons are configured such that there are paired valence electrons in an *s* orbital. Group 13 (IIIA) elements, which include boron and aluminum, have a single electron in the outermost *p* orbital. Less energy is needed to remove a single electron from a *p* orbital than to remove an electron from an *s* orbital in the same energy level; therefore Group 13 (IIIA) elements have lower first ionization energies than Group 2 (IIA) elements.

Question Source:

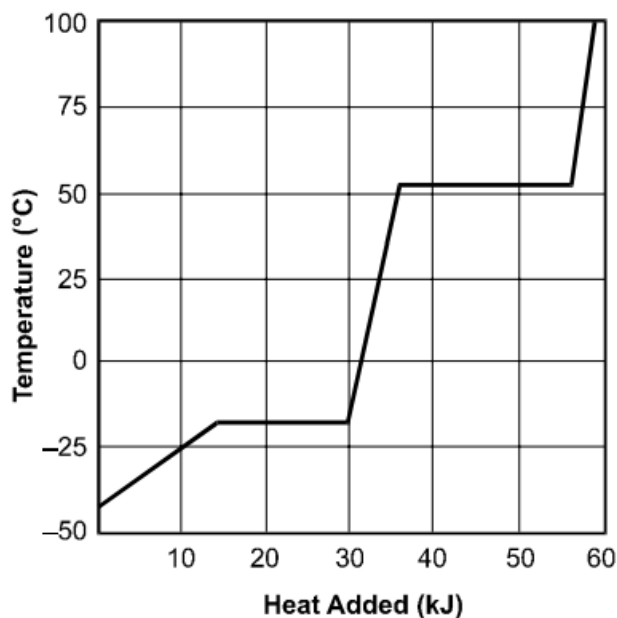
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The two graphs below show the hypothetical heating curves for equal molar amounts of two substances, X and Y.

Heating Curve for Substance X



Heating Curve for Substance Y



Based on the heating curves, which of the following conclusions comparing the two substances is correct?

- A. The specific heat of substance Y in its liquid state is greater than the specific heat of substance X in its liquid state.
- B. The molar heat of fusion of substance Y is greater than the molar heat of fusion of substance X.
- C. The molar heat of vaporization of substance X is greater than the molar heat of vaporization of substance Y.
- D. The boiling point of substance X is greater than the boiling point of substance Y.

Correct Response: B. A heating curve represents the change in temperature of a substance as heat is added. Of the choices listed, only B is consistent with the data provided in the graphs. The molar heat of fusion is the amount of heat required to melt one mole of a substance, represented on the graphs by the lower horizontal segment. A longer horizontal segment indicates that more heat is required to melt all of the substance. In the graphs, the horizontal segment indicating the melting point is longer for substance Y than for substance X, so it can be concluded that its molar heat of fusion is greater.

Question Source:

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Use the information below to answer the question that follows.

${}^1_1\text{H}$	mass = 1.007825 amu
neutron	mass = 1.008665 amu

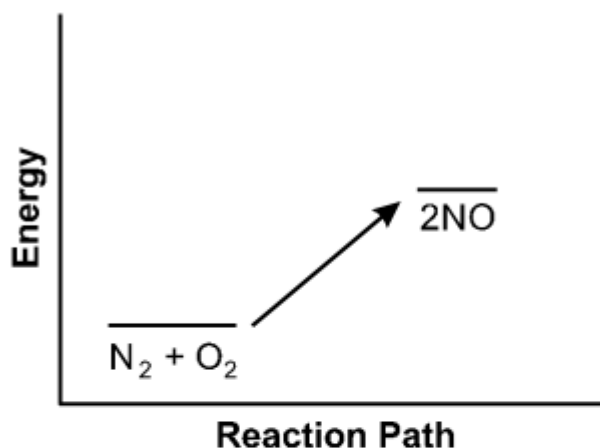
The experimentally determined nuclear mass of ${}^{35}_{17}\text{Cl}$ is 34.95952 amu. Based on this information, what is the nuclear mass defect of the chlorine-35 nucleus?

- A. 0.31436 amu
- B. 0.32864 amu
- C. 0.32948 amu
- D. 0.34376 amu

Correct Response: C. The nuclear mass defect is the difference between the mass of the nucleus and the sum of the masses of the individual protons and neutrons from which it is composed. The chlorine-35 nucleus has 17 protons and 18 neutrons. Seventeen times the mass of a proton (1.007825 amu) plus 18 times the mass of a neutron (1.008665 amu) is 35.28900 amu. This sum differs from the experimentally determined nuclear mass of 34.95952 amu by 0.32948 amu.

Question Source:

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Shown above is the potential energy diagram for the chemical reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$. Based on the diagram, which of the following statements is true for this reaction?

- A. The reaction absorbs energy.
- B. The reactants have more potential energy than the products.
- C. The reaction is exothermic.
- D. The change in potential energy is negative.

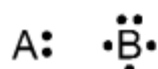
Correct Response: A. The potential energy diagram for this chemical reactions shows that the reactants have less energy than the products. Therefore, the reactants need to absorb energy in order to be converted into products. Reactions that absorb energy are endothermic.

Question Source:

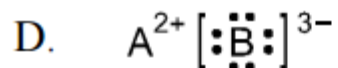
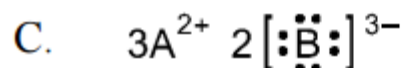
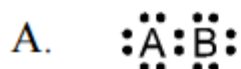
NYSTCE (New York) Chemistry Sample Test

Use the information below to answer the question that follows.

The Lewis dot structures for atoms of two hypothetical elements, A and B, are shown below.



The two elements react, forming an ionic compound. Which of the following correctly shows the resulting product using Lewis dot symbols?



Correct Response: C. The Lewis dot structure of element A indicates that it is an alkaline earth metal (group 2), which means that it will form +2 cations by losing electrons. The Lewis dot structure of element B indicates that it is from group 15 and will attract electrons to form -3 anions. When ionic bonds form between atoms of these elements, the two outer valence electrons of A are transferred to the B atoms. Since each atom of A has only two outer valence electrons to offer and each atom of B needs three electrons to fill its outer valence shell, the ratio of A to B atoms needs to be 3:2 to result in an electrically neutral compound. Thus, C correctly represents the ionic compound using Lewis dot symbols.

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Hydrogen bonds are found between molecules containing hydrogen and:

- A. bromine.
- B. carbon.
- C. fluorine.
- D. selenium.

Correct Response: C. A hydrogen bond is a strong intermolecular force that occurs when a hydrogen atom that is covalently bonded in one molecule is simultaneously attracted to an atom in another molecule. For this to occur, the atoms to which the hydrogen is both bonded and attracted must be small and highly electronegative. The only atoms that are both small and electronegative enough to be involved in hydrogen bonding are nitrogen, oxygen, and fluorine. Therefore, of the choices listed, only molecules containing hydrogen and fluorine are capable of hydrogen bonding.

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Which of the following types of substances are very hard, melt at very high temperatures, and are nonconductors of electricity?

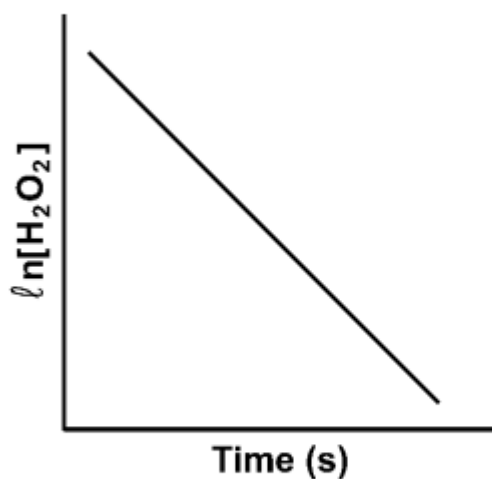
- A. amorphous solids
- B. ionic solids
- C. metallic solids
- D. network solids

Correct Response: D. Network solids are held together by an extensive network of covalent bonds in three dimensions. To break these bonds requires a large amount of energy. Moreover, because the network of covalent bonds is extensive, the melting point for these substances is quite high. The three-dimensional nature of the covalent bonding makes the network stiff, inflexible, and very hard. Furthermore, there are no free ions in the structure available to conduct electricity. Therefore, of the choices listed, network solids best match the listed properties.

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Use the information below to answer the question that follows.



The graph above shows data for the decomposition of H_2O_2 . The graph indicates that this reaction is:

- A. zero order.
- B. first order.
- C. second order.
- D. third order.

Correct Response: B. The rate of the reaction for the first order decomposition of hydrogen peroxide can be expressed as:

$$\text{rate} = \frac{-\Delta[\text{H}_2\text{O}_2]}{\Delta t} \text{ or as } \text{rate} = k[\text{H}_2\text{O}_2].$$

Setting these two equations equal to each other yields $\frac{-\Delta[\text{H}_2\text{O}_2]}{\Delta t} = k[\text{H}_2\text{O}_2]$. Integrating

this equation using calculus yields $\ln \frac{[\text{H}_2\text{O}_2]}{[\text{H}_2\text{O}_2]_0} = -kt$, which can be rewritten as

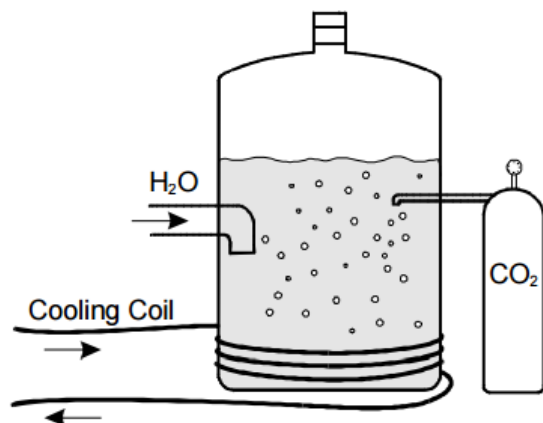
$\ln[\text{H}_2\text{O}_2] = -kt + \ln[\text{H}_2\text{O}_2]_0$. This latter equation follows the format for a linear equation,

$y = mx + b$, where the y-axis is $\ln[\text{H}_2\text{O}_2]$ and the x-axis is time.

Question Source:

NYSTCE (New York) Chemistry Sample Test

Use the diagram below to answer the two questions that follow.



In the beverage industry, carbon dioxide is introduced into a pressure vessel containing flavored sugar water to give the characteristic fizz associated with soda. After the system has reached equilibrium, the carbonated water is sent through tubing to be bottled.

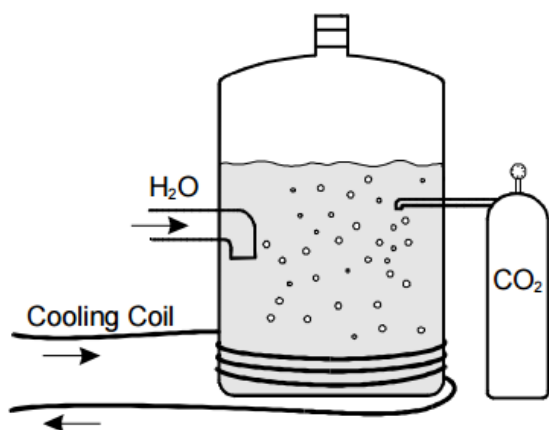
During the manufacturing process, which of the following conditions would shift the equilibrium to favor a reduced carbon dioxide concentration in the beverage?

- A. a leak in the pressure vessel
- B. a decrease in the temperature of the cooling coil
- C. an increase in the length of time the carbon dioxide is left in contact with the sugar water
- D. an increase in the level to which the vessel is filled with sugar water

Correct Response: A. Several factors can affect chemical equilibrium, but in the situation described, temperature and pressure are likely to be of the greatest concern. Either an increased temperature or a decreased pressure would be unfavorable to carbon dioxide going into solution. Therefore, of the choices listed, only a leak in the pressure vessel, which would lower the system's pressure, is likely to cause the beverage to have a reduced carbon dioxide concentration.

Question Source:

NYSTCE (New York) Chemistry Sample Test



In the beverage industry, carbon dioxide is introduced into a pressure vessel containing flavored sugar water to give the characteristic fizz associated with soda. After the system has reached equilibrium, the carbonated water is sent through tubing to be bottled.

To calculate the amount of energy required for the cooling coil to bring the contents of the vessel to the desired temperature, which of the following information is needed?

- I. desired temperature decrease
 - II. specific heat of the sugar water
 - III. volume and density of the sugar water
 - IV. molecular weight of the sugar water
- A. I and IV only
- B. II and III only
- C. I, II, and III only
- D. I, III, and IV only

Correct Response: C. Several pieces of information are required to determine the amount of energy needed to cool the vessel contents. First, one must know how many degrees Celsius the contents are to be cooled. Another important piece of information is this particular solution's specific heat, the amount of energy necessary to change the temperature of one gram of the solution by one degree Celsius. Finally, the volume and density of the sugar water can be used to calculate the mass of sugar water in the vessel. So the information identified in options I, II, and III is required to make the calculation.

Question Source:

NYSTCE (New York) Chemistry Sample Test

What is the pH of a 0.115 M solution of NH_3 ? ($K_b \text{ NH}_3 = 1.8 \times 10^{-5}$)

- A. 2.84
- B. 8.32
- C. 10.2
- D. 11.2

Correct Response: D. The equilibrium for the weak base ammonia is represented by the following reaction: $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$. The equilibrium expression for this reaction is $K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]}$, where $[\text{NH}_4^+] = [\text{OH}^-]$. Using the given values for K_b and $[\text{NH}_3]$ (assuming that the small amount of dissociation does not change initial $[\text{NH}_3]$), the expression can be solved, yielding a hydroxide ion concentration of 0.00144 M. This value is used to calculate the pH of the solution by the following steps:

$$\text{pOH} = -\log 0.00144 = 2.84$$

$$\text{pH} = 14.00 - 2.84 = 11.2$$

Question Source:

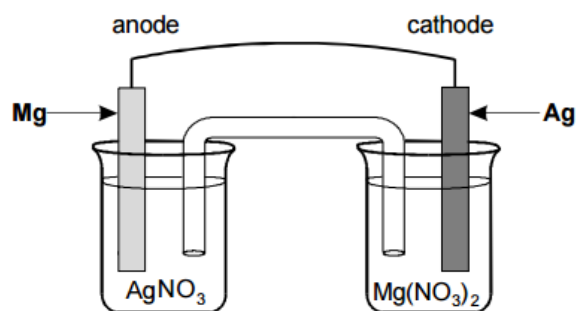
NYSTCE (New York) Chemistry Sample Test

Use the information below to answer the question that follows.

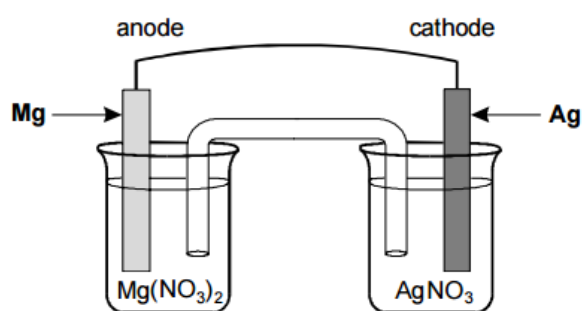
Half-Reaction	Standard Reduction Potential
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	0.80 V
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.37 V

Which of the following diagrams correctly illustrates the electrochemical cell for the cell reactions above?

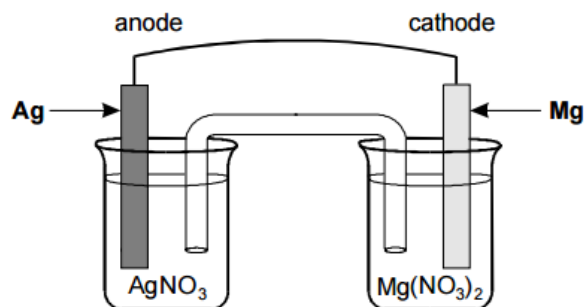
A.



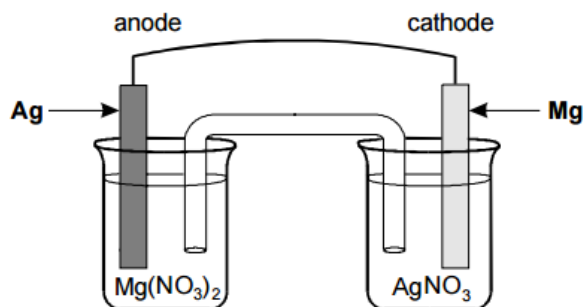
B.



C.



D.

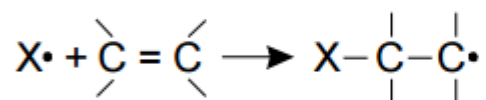


Correct Response: B. The standard reduction potentials for the silver and magnesium ions are $+0.80\text{ V}$ and -2.37 V , respectively. Spontaneous electrochemical cells must have positive voltages, so the magnesium half reaction will run as an oxidation at $+2.37\text{ V}$. The anode is the electrode where oxidation takes place. Solid magnesium will be oxidized into the magnesium ion in this cell. The reduction of the silver ion to solid silver will occur at the cathode.

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A small molecule joins with other identical molecules in an addition reaction catalyzed by a free radical, as shown in the diagram below. As the reaction continues, long chains are formed, each with an unpaired electron at one end. The process terminates when two of these chains combine.



Compounds formed by the process described above are most likely to be associated with:

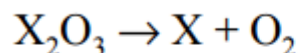
- A. plastic products.
- B. nuclear waste products.
- C. DNA synthesis.
- D. cancer cell proliferation.

Correct Response: A. The reaction describes an addition polymerization process. Depending on what atoms or functional groups are attached to the carbon atoms, the long chain molecules form products such as polyethylene, polypropylene, and polyvinyl chloride. These materials are used to make various plastic products such as bottles, packaging films, and piping.

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An oxide of element X can be made to decompose according to the following unbalanced reaction.



When 306 grams of X_2O_3 are dissociated, 4.50 moles of O_2 are produced. What is the approximate gram atomic mass of X?

- A. 6.90 amu
- B. 10.8 amu
- C. 13.5 amu
- D. 27.0 amu

Correct Response: D. First the equation must be balanced, giving $2X_2O_3 \rightarrow 4X + 3O_2$. Since 4.5 moles of O_2 are produced in the reaction, the initial molar amount of X_2O_3 can be calculated using the relationship $\frac{4.5}{3} = \frac{x}{2}$. Thus, 306 grams of X_2O_3 is 3 moles. The mass of the oxygen in 3 moles of X_2O_3 is calculated by multiplying the atomic mass of oxygen (16.0 amu) by the total number of oxygen atoms (9), which is 144 g of oxygen. The remaining 162 g is the element X, and to calculate its gram atomic mass, 162 is divided by 6, the total number of atoms of element X in 3 moles of X_2O_3 . Therefore, the answer is 27.0 amu.

Question Source:

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What is the percent of hydrogen by mass
in $(\text{CH}_3)_2\text{CHCOOH}$?

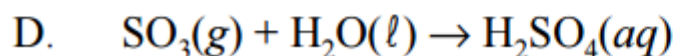
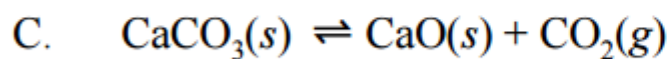
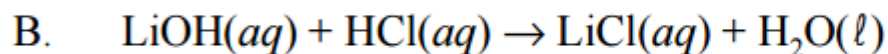
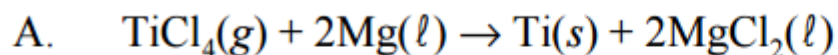
- A. 3.48%
- B. 4.26%
- C. 6.91%
- D. 9.17%

Correct Response: D. According to the formula, there are 4 moles of carbon, 8 moles of hydrogen, and 2 moles of oxygen in 1 mole of the compound. Using molar masses for these elements from the periodic table, the molar mass of the compound is 88.12 g/mol. Of this total, 8.08 grams is contributed by hydrogen. Thus, the percent of hydrogen by mass is given by the expression, $\frac{8.08 \text{ g}}{88.12 \text{ g}} \times 100\%$, which is 9.17%.

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NYSTCE (New York) Chemistry Sample Test

Which of the following equations represents an oxidation-reduction reaction?

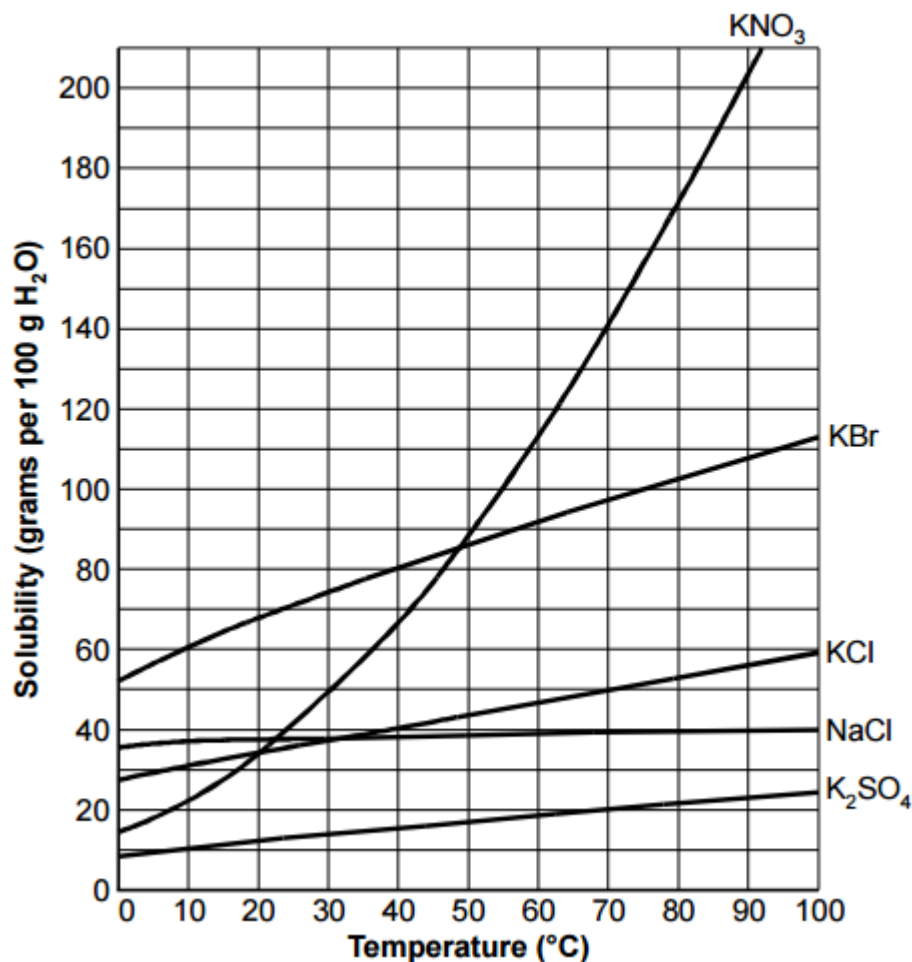


Correct Response: A. Oxidation-reduction reactions are characterized by changes in the oxidation numbers of the atoms involved. The oxidation number of one atom is increased (the oxidation), while the oxidation number of another atom is decreased (the reduction). In the reaction between titanium(IV) chloride and magnesium, the titanium atom is reduced from a +4 oxidation number as a reactant to zero when elemental as a product. Paired with this reduction is the oxidation of magnesium from neutral as the element to +2 when in a compound with the chloride ion.

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Use the solubility graph below to answer the question that follows.



A 90 g sample of KNO₃ is contaminated with 10 g of NaCl. In order to obtain pure KNO₃, the mixture is dissolved in 100 mL of H₂O at 80°C. At what temperature will approximately 75 g of pure KNO₃ crystallize from the prepared solution?

- A. 0°C
- B. 22°C
- C. 45°C
- D. 55°C

Correct Response: A. As the solution is cooled, the solubility of the solutes decreases. At about 50°C, KNO_3 will start to crystallize out of solution, as 90 g KNO_3 /100 g H_2O is the saturation amount at this temperature. If the solution is cooled down to 0°C, only about 15 grams of KNO_3 can remain dissolved, so approximately 75 grams of KNO_3 (90 g – 15 g) will have crystallized at this temperature. The solubility of NaCl is above 10 g/100 g H_2O at all temperatures shown, so no NaCl will crystallize.

Question Source:

NYSTCE (New York) Chemistry Sample Test

A well-maintained, properly running nuclear power plant uses water from a nearby river to help cool the reactor. People living downstream from the power plant have noticed many dead fish in the area. Based on this information, the dead fish are most likely the result of:

- A. dissolved oxygen in the water being limited due to the increased temperature of the cooling water.
- B. radioactive isotopes with a very long half-life being released into the water.
- C. heavy water meant to be pumped into the moderator being accidentally released into the river.
- D. dissolved metals from the containment vessel being released into the water.

Correct Response: A. Since the nuclear power plant uses river water for cooling, the water is discharged back to the river at a higher temperature. The solubility of gases, such as oxygen, decreases as the temperature of the water increases. Therefore, if the temperature of the downstream river water is increased significantly by the power plant, the amount of dissolved oxygen may decrease below levels required by certain aquatic species.

Question Source:

NYSTCE (New York) Chemistry Sample Test

^{32}P and ^{131}I are radioactive isotopes used to treat bone marrow and thyroid cancer. Their usefulness is in part due to their tendency to concentrate in specific organs. Which of the following characteristics is also necessary to make an isotope a good candidate for this form of radiotherapy?

- A. The isotope emits only alpha radiation.
- B. The isotope has a short half-life.
- C. The isotope produces primarily heat energy rather than particle emissions.
- D. The isotope's decay rate is constant.

Correct Response: B. While radioactive isotopes do play beneficial roles in treating certain human diseases, they pose a threat to healthy tissue because they are radioactive. Isotopes that have a short half-life are desirable for treating cancers in targeted areas of the body because they do not remain long enough in high concentrations in the body to cause damage to normal, healthy tissue.

Question Source:

NYSTCE (New York) Chemistry Sample Test

When wastewater containing phosphates is released into lakes and ponds, eutrophication often occurs. Which of the following best describes the role of the phosphates in this process?

- A. They act as chelating agents, depriving fish of nutrients.
- B. They precipitate calcium ions, which increases the turbidity of the water.
- C. They act as acids, lowering the pH of the water.
- D. They cause algae to grow rapidly, which depletes dissolved oxygen.

Correct Response: D. Phosphates act as a source of phosphorus, an important plant nutrient. Waters rich in plant nutrients can support a bloom of algae, a microscopic photosynthetic plant. While daylight will lead to oxygen production, nighttime-dissolved oxygen levels are greatly reduced due to respiration of the excessive biomass. An increased level of organic materials in the lake will also support a larger population of decomposers, which respire and consume dissolved oxygen as well.

Question Source:

NYSTCE (New York) Chemistry Sample Test

A student wearing appropriate safety equipment is performing a chemistry laboratory investigation to determine the value of the gas constant, R , as used in the ideal gas equation. To achieve this, the pressure, volume, moles, and temperature of a single gas sample will be determined.

The student uses the procedure below to carry out this investigation.

1. Fill a pan and a 100-mL graduated cylinder with cold tap water. Cover the top of the graduated cylinder with plastic wrap, ensuring that there are no air bubbles trapped under the plastic. Quickly invert the graduated cylinder into the pan of water and hold it in place. Remove the plastic wrap.
2. Measure and record the mass of a disposable butane lighter. Hold the lighter underwater just below the mouth of the inverted graduated cylinder.
3. Open the trigger of the lighter to release butane gas into the graduated cylinder. Collect 100 mL of butane gas in the graduated cylinder.
4. Remove the lighter from the water and measure its mass again. Calculate the mass difference from before and after releasing the gas. The mass difference represents the mass of the 100 mL of butane gas in the graduated cylinder. Calculate the moles of butane (C_4H_{10}).
5. Record the atmospheric pressure and temperature in the laboratory.
6. Insert the collected data into the ideal gas law equation to solve for the constant, R .

Using your knowledge of laboratory techniques, prepare a response in which you:

- identify two weaknesses of the procedure described above and explain why, from a scientific perspective, they are weaknesses; and
- describe two modifications that should be made to the procedure to address the identified weaknesses and explain how these changes would enhance the scientific validity of the results.

There are several weaknesses in the procedure. In step 1 the student fills the pan and cylinder with cold water. This would entail a significant difference between the temperature of the laboratory later recorded and the temperature of the gas. If the student assumes that the temperature of the collected $C_4H_{10}(G)$ is the same as the temperature of the laboratory, she will be using the wrong value for T in the ideal gas equation $PV = nRT$.

To remedy this weakness, the student should fill the pan and cylinder with water that has been allowed to come to room temperature. Thus the temperature of the butane and that of the room will be the same, and the resulting calculations will be more accurate.

A second weakness is that the pressure of the water vapor in the graduated cylinder is not accounted for. The total pressure of the gases in the cylinder is the sum of the pressure of the butane gas plus the pressure of the water vapor ($P_T = P_{H_2O} + P_{C_4H_{10}}$). If the student does not factor in the water vapor pressure, the value she uses for P will be greater than the actual value of the pressure of the butane gas. This will result in an erroneously high calculation of R .

To address this weakness, the student should use a reference table to determine the vapor pressure of water at the experimental temperature. The student should then subtract this value from the atmospheric pressure measured in step 5; the difference will represent the pressure of the butane gas. Her use of this adjusted value will result in a more accurate determination of the value of R .