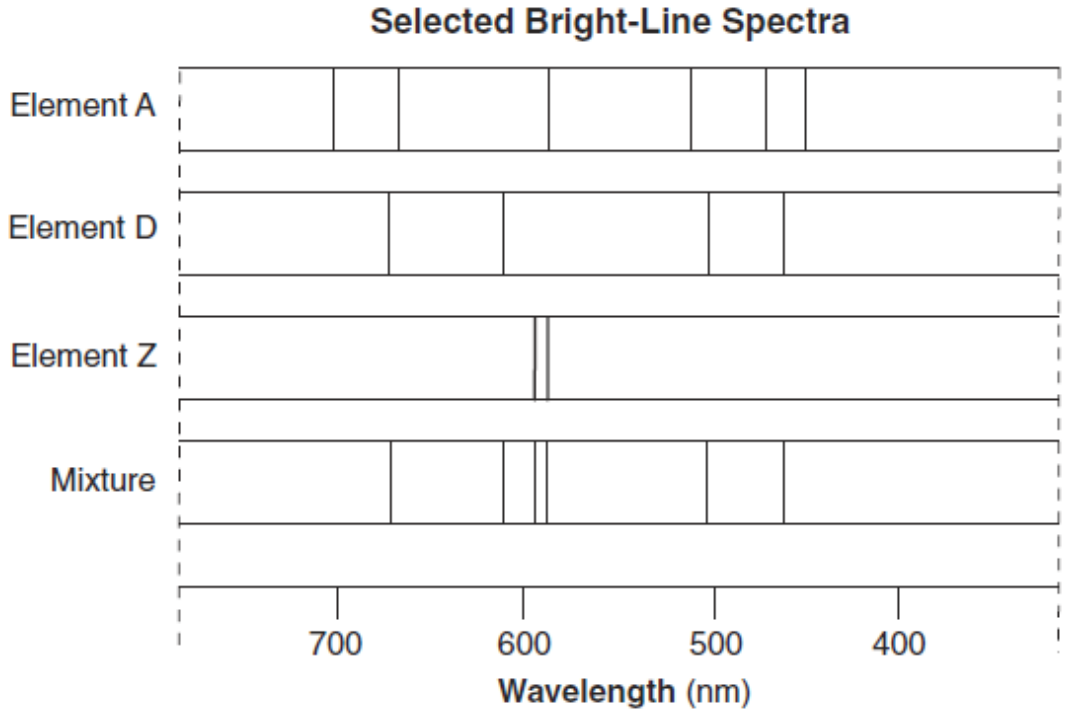
1. Base your answer to the following question on the information below and on your knowledge of chemistry.

   The bright-line spectra observed in a spectroscope for three elements and a mixture of two of these elements are represented in the diagram below.



   Describe, in terms of *both* electrons and energy state, how the light represented by the spectral lines is produced.

2. Explain, in terms of element classification, why K_2O is an ionic compound.

3. Base your answer to the following question on the information below and on your knowledge of chemistry.

   Illuminated **EXIT** signs are used in public buildings such as schools. If the word **EXIT** is green, the sign may contain the radioisotope tritium, hydrogen-3. The tritium is a gas sealed in glass tubes. The emissions from the decay of the tritium gas cause a coating on the inside of the tubes to glow.

   State, in terms of neutrons, how an atom of tritium *differs* from an atom of hydrogen-1.

Base your answers to questions **4** and **5** on the information below and on your knowledge of chemistry.

The Lewis electron-dot diagrams for three substances are shown below.

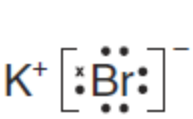


Diagram 1

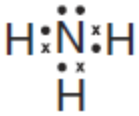


Diagram 2

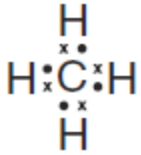


Diagram 3

4. Explain, in terms of distribution of charge, why a molecule of the substance represented in diagram 3 is nonpolar.

5. Describe, in terms of valence electrons, how the chemical bonds form in the substance represented in diagram 1.

Base your answers to questions **6** and **7** on the information below and on your knowledge of chemistry.

A student made a copper bracelet by hammering a small copper bar into the desired shape. The bracelet has a mass of 30.1 grams and was at a temperature of 21°C in the classroom. After the student wore the bracelet, the bracelet reached a temperature of 33°C. Later, the student removed the bracelet and placed it on a desk at home, where it cooled from 33°C to 19°C. The specific heat capacity of copper is 0.385 J/g• K.

6. Explain, in terms of chemical activity, why copper is a better choice than iron to make the bracelet.

7. Explain, in terms of heat flow, the change in the temperature of the bracelet when the student wore the bracelet.

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8. Base your answer to the following question on the information below and on your knowledge of chemistry.

Rubbing alcohol is a product available at most pharmacies and supermarkets. One rubbing alcohol solution contains 2-propanol and water. The boiling point of 2-propanol is 82.3°C at standard pressure.

Explain in terms of electronegativity differences, why a C–O bond is more polar than a C–H bond.

9. Base your answer to the following question on the information below and on your knowledge of chemistry.

The balanced equation below represents a reaction.

$$O_2(g) + \text{energy} \rightarrow O(g) + O(g)$$

Explain, in terms of bonds, why energy is absorbed during this reaction.

10. Base your answer to the following question on the information below and on your knowledge of chemistry.

A laboratory technician is given the table below and a sample of one of the three substances listed in the table. The technician makes an aqueous solution with a portion of the sample. When a conductivity tester is lowered into the solution, the lightbulb on the tester glows brightly. Another portion of the sample is placed in a heat-resistant container that is placed in an oven at 450°C. The sample melts.

Some Properties of Three Substances

Property	Substance		
	Sodium nitrate	Potassium chromate	Sulfur
solubility in water at 20.°C	soluble	soluble	insoluble
electrical conductivity of aqueous solution	good	good	not applicable
melting point (°C)	307	974	115

Explain, in terms of ions, why an aqueous solution of potassium chromate conducts an electric current.

Base your answers to questions **11** and **12** on the information below and on your knowledge of chemistry.

Hydrazine, N_2H_4, is a compound that is very soluble in water and has a boiling point of 113°C at standard pressure. Unlike water, hydrazine is very reactive and is sometimes used as a fuel for small rockets. One hydrazine reaction producing gaseous products is represented by the balanced equation below.

$$N_2H_4(\ell) \rightarrow N_2(g) + 2H_2(g) + \text{heat}$$

11. Explain, in terms of intermolecular forces, why the boiling point of hydrazine at standard pressure is higher than the boiling point of water as standard pressure.

12. Explain, in terms of molecular polarity, why N_2H_4 is very soluble in water.

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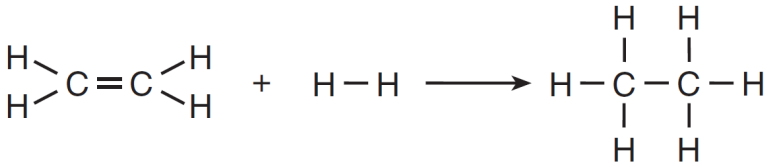
13. Base your answer to the following question on the information below and on your knowledge of chemistry.

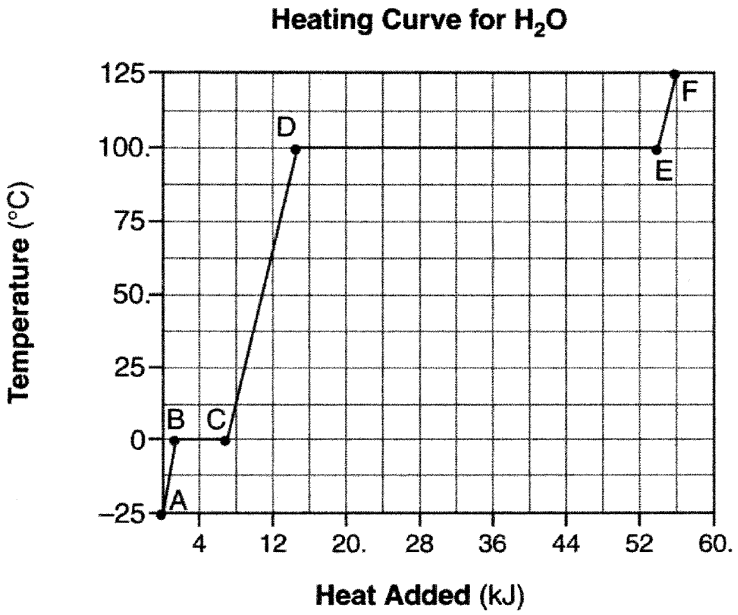
Ethene and hydrogen can react at a faster rate in the presence of the catalyst platinum. The equation below represents a reaction between ethene and hydrogen.



Explain, in terms of activation energy, why the catalyzed reaction occurs at a faster rate.

14. Base your answer to the following question on the information below and on your knowledge of chemistry.

Starting as a solid at –25°C, a sample of H_2O is heated at a constant rate until the sample is at 125°C. This heating occurs at standard pressure. The graph below represents the relationship between temperature and heat added to the sample.



Explain, in terms of heat of fusion and heat of vaporization, why the heat added during interval *DE* is greater than the heat added during interval *BC* for this sample of water.

15. Base your answer to the following question on the information below and on your knowledge of chemistry.

lodine has many isotopes, but only iodine-127 is stable and is found in nature. One radioactive iodine isotope, I-108, decays by alpha particle emission. Iodine-131 is also radioactive and has many important medical uses.

Explain, in terms of protons and neutrons, why I-127 and I-131 are different isotopes of iodine.

16. Base your answer to the following question on the information below.

Nitrogen gas and oxygen gas make up about 99% of Earth's atmosphere. Other atmospheric gases include argon, carbon dioxide, methane, ozone, hydrogen, etc.
The amount of carbon dioxide in the atmosphere can vary. Data for the concentration of CO2(g) from 1960 to 2000 are shown in the table below.

Atmospheric Concentration of $CO_2(g)$

Year	Concentration (ppm)
1960	316.9
1980	338.7
2000	369.4

Explain, in terms of types of matter, why methane can be broken down by chemical means, but argon can *not* be broken down by chemical means. Your response must include *both methane and argon.*

17. Base your answer to the following question on the information below.

At standard pressure, hydrogen peroxide, H_2O_2, melts at –0.4°C, boils at 151°C, and is very soluble in water. A bottle of aqueous hydrogen peroxide, $H_2O_2(aq)$, purchased from a pharmacy has a pressure-releasing cap. Aqueous hydrogen peroxide decomposes at room temperature, as represented by the balanced equation below.

$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g) + 196.0\ kJ$

State, in terms of *both* melting point and boiling point, why H_2O_2 is a liquid at room temperature.

18. Base your answer to the following question on the information below and on your knowledge of chemistry.

Fossil fuels produce air pollution and may eventually be depleted. Scientists are researching ways to use hydrogen as an alternate fuel.

A device called an artificial leaf was invented to produce hydrogen and oxygen using sunlight and water. The artificial leaf is an electrochemical cell. Equation 1 and 2 below represent the reactions taking place in the leaf. Equation 3 represents a reaction of hydrogen when used as fuel.

$\text{Equation 1}: \ 2H_2O + \text{energy from sunlight} \rightarrow O_2 + 4H^+ + 4e^-$
$\text{Equation 2}: \ 4H^+ + 4e^- \rightarrow 2H_2$
$\text{Equation 3}: \ 2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \ + \ \text{energy}$

Explain, in terms of energy, why the artificial leaf is an electrolytic cell.

19. Base your answer to the following question on the information below.

Some carbonated beverages are made by forcing carbon dioxide gas into a beverage solution. When a bottle of one kind of carbonated beverage is first opened, the beverage has a pH value of 3.

State, in terms of the pH scale, why this beverage is classified as acidic.

20. Base your answer to the following question on the information below and on your knowledge of chemistry.

The diagrams below represent ball-and-stick models of two molecules. In a ball-and-stick model, each ball represents an atom, and the sticks between balls represent chemical bonds.

Key
● = an atom of hydrogen
○ = an atom of carbon

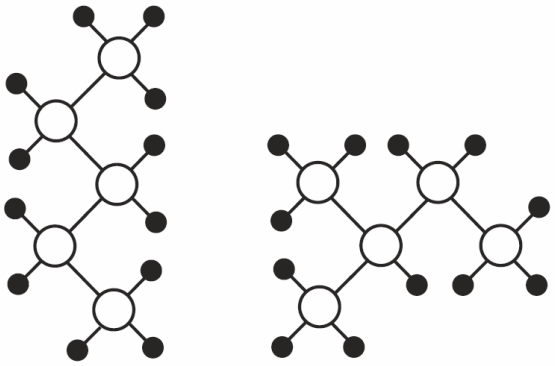


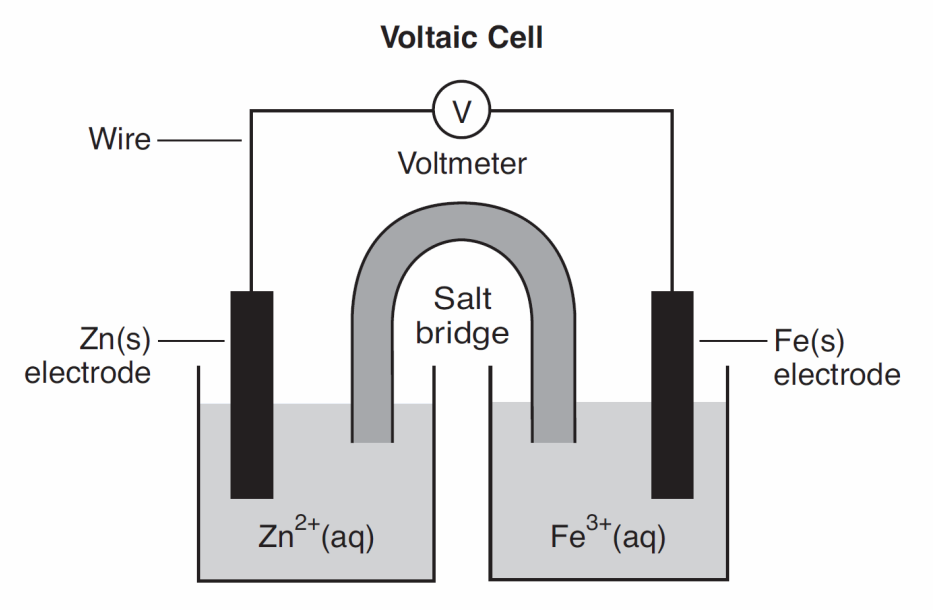
Diagram A

Diagram B

Explain, in terms of carbon-carbon bonds, why the hydrocarbon represented in diagram *B* is saturated.

21. Base your answer to the following question on the information below and on your knowledge of chemistry.

An operating voltaic cell has zinc and iron electrodes. The cell and the unbalanced ionic equation representing the reaction that occurs in the cell are shown below.

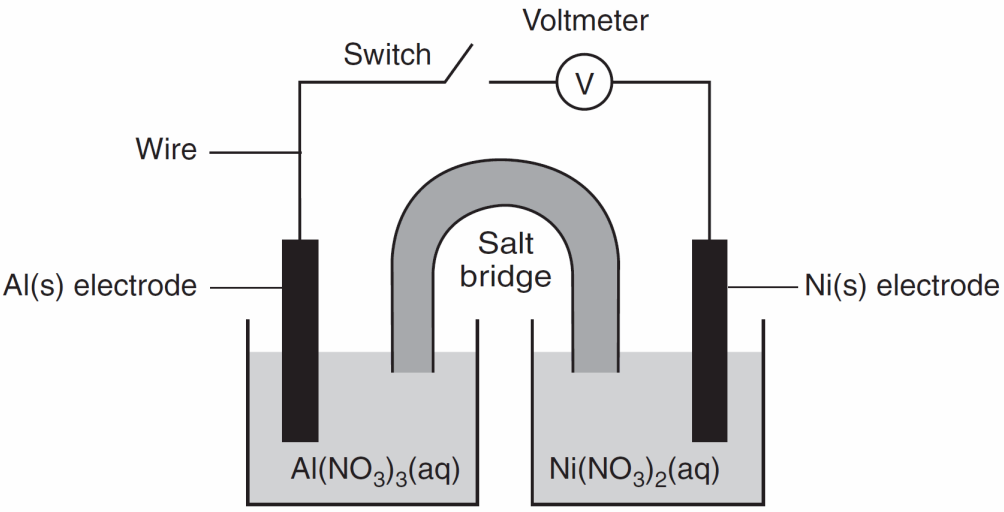


$$Zn(s) + Fe^{3+}(aq) \rightarrow Zn^{2+}(aq) + Fe(s)$$

Explain, in terms of Zn atoms and Zn ions, why the mass of the Zn electrode *decreases as the cell operates.*

22. Base your answer to the following question on the information below.

A student constructs an electrochemical cell during a laboratory investigation. When the switch is closed, electrons flow through the external circuit. The diagram and equation below represent this cell and the reaction that occurs.

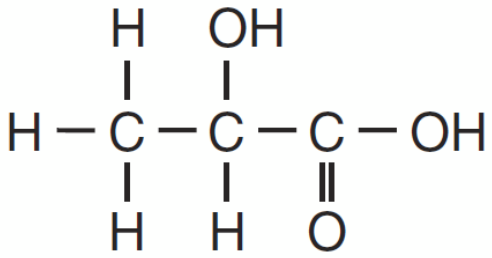


$$2Al(s) + 3Ni^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$$

State, in terms of energy, why this cell is a voltaic cell.

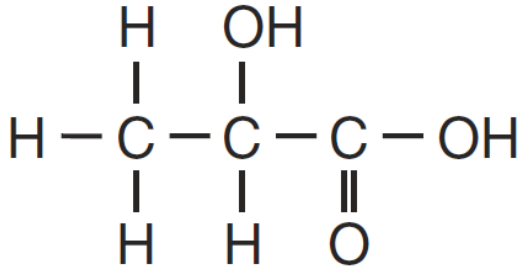
23. Base your answer to the following question on the information below and on your knowledge of chemistry.

A student makes an aqueous solution of lactic acid. A formula for one form of lactic acid is shown below.



The solution is placed in a sealed flask to be used in a laboratory investigation. The equation below represents the lactic acid equilibrium system in the flask

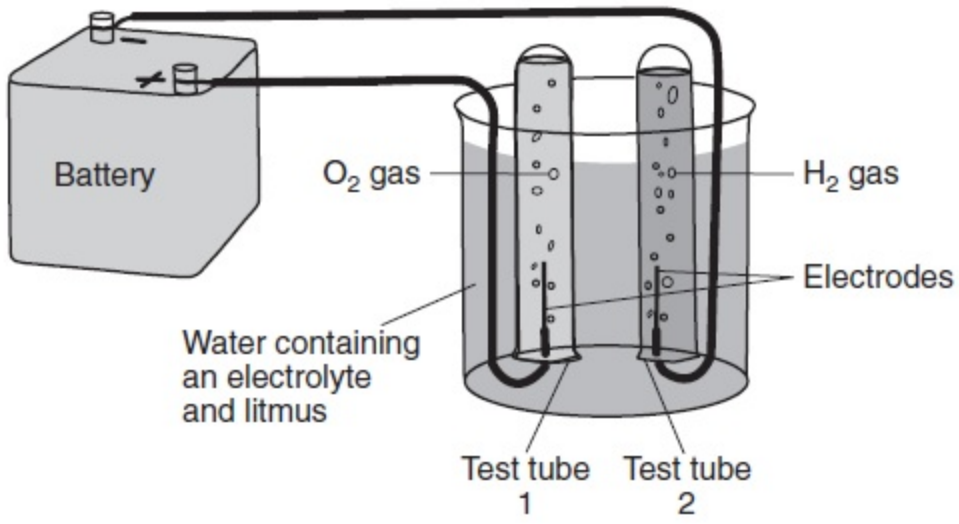
$$\underset{\text{lactic acid}}{CH_3CHOHCOOH(aq)} \rightleftharpoons H^+(aq) + \underset{\text{lactate ion}}{CH_3CHOHCOO^-(aq)}$$



Explain, in terms of the reaction rates, why the concentrations of the reactants and products remain constant in this system.

24. Base your answer to the following question on the information below.

The diagram below shows a system in which water is being decomposed into oxygen gas and hydrogen gas. Litmus is used as an indicator in the water. The litmus turns red in test tube 1 and blue in test tube 2.



The oxidation and reduction occurring in the test tubes are represented by the balanced equations below.

Test tube 1: $2H_2O(\ell) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Test tube 2: $4H_2O(\ell) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$

Explain, in terms of the products formed in test tube 2, why litmus turns blue in test tube 2.

25. Base your answer to the following question on the information below.

In the early 1800s, John Dalton proposed an atomic theory that was based on experimental observations made by several scientists. Three concepts of Daltons atomic theory are stated below.

Statement *A*: Atoms are indivisible and cannot be destroyed or broken down into smaller parts.
Statement *B*: Atoms of one element cannot be changed into atoms of another element.
Statement *C*: All atoms of one element have the same mass.

Explain, in terms of particles in the atoms of an element, why statement *C* is *false*.

Answer Key
In Terms of practice

1. —Different colors of light are produced when electrons return from higher energy states to lower energy states. —Light energy can be emitted when electrons in excited atoms return to lower shells. —Electrons release energy as they move toward the ground state.
2. —A metal reacts with a nonmetal to produce an ionic compound. —Potassium is a metal and oxygen is a nonmetal.
3. –A tritium atom has two neutrons and an H-1 atom has no neutrons. –Only the tritium atom has neutrons. –H-1 has no neutrons.
4. —Charge is symmetrically distributed. —The molecule has uniform charge distribution. —The centers of positive charge and negative charge coincide.
5. —Valence electrons are lost by potassium and gained by bromine. —The ions form as a result of a transfer of electrons between the atoms.
6. –Copper is less chemically active than iron, so copper is less likely to react with substances in the air or on the skin. –Iron is more active. –Fe oxidizes more easily.
7. –The bracelet temperature increased because heat flowed from the body to the copper. –Energy is transferred from the student to the bracelet. –Heat is absorbed by the bracelet.
8. – There is a greater electronegativity difference in a CO bond than in a CH bond. – The CO bond is more polar because the electronegativity difference for a CO bond is 0.8, and the electronegativity difference for a CH bond is 0.4. – The CH bond has a smaller difference. – The CO is .8 and the CH is .4
9. –Energy is needed to break the bonds in O_2.
10. —An aqueous solution of potassium chromate has mobile ions that conduct electricity. —The K_2CrO_4 dissociated into mobile ions. —Aqueous potassium chromate has charged particles that can move. —The $K^+(aq)$ and $CrO_4{}^{2-}(aq)$ move freely.
11. —The intermolecular forces in hydrazine must be greater than the intermolecular forces in water. —The intermolecular forces in H_2O are weaker.
12. —Hydrazine is very soluble in water because the molecular polarity of hydrazine is similar to the molecular polarity of water. —Water and hydrazine are both polar.
13. – The catalyzed reaction pathway has a lower activation energy than the original reaction. – Less energy is needed.
14. –The heat of vaporization of water is 2260 J/g and the heat of fusion for water is only 334 J/g. –The heat of fusion of water is much less than its heat of vaporization.

Answer Key
In Terms of practice

15. – I-127 atoms and I-131 atoms have the same number of protons, but different numbers of neutrons. – Both have 53 p, but I-127 has 74 n while I-131 has 78 n. – They have the same atomic number but different mass numbers. – same atomic number but different numbers of neutrons – The only difference is the number of neutrons.

16. –Methane is a compound consisting of two elements, so it can be broken down by chemical means, but argon is an element, which cannot be broken down. –Methane is a compound and argon is an element.

17. —Room temperature is above the melting point and below the boiling point of H_2O_2. —Room temperature is between –0.4°C and 151°C. —–0.4°C < room temperature < 151°C

18. —Sunlight is used as an external power source for the cell. —Sunlight is required to cause a nonspontaneous chemical change. —Energy is required.

19. – The beverage is acidic because its pH value is below 7. – A pH of 3 is in the acid range on the pH scale.

20. –The molecule in diagram *B* has only single carbon-carbon bonds. –There are no multiple bonds between the carbon atoms. –Cannot add more H atoms to the C atoms because all C–C bonds are single.

21. –Zinc atoms from the electrode are oxidized to zinc ions in the solution, decreasing the mass of the electrode. –Zinc atoms become Zn^{2+} (aq). –The atoms become ions dissolved in the water. –Zn atoms lose electrons, producing ions in solution.

22. —A spontaneous reaction converts chemical energy to electrical energy. —A battery is not required to provide energy for the cell to operate.

23. –The rate of the forward reaction equals the rate of the reverse reaction. –The reaction rates are the same at equilibrium.

24. • Litmus turns blue when a sufficient amount of hydroxide ions are produced. • The reaction in test tube 2 produces OH^- ions that make this solution basic. Litmus is blue in a basic solution.

25. Acceptable responses include, but are not limited to: • Atoms of different isotopes of an element have different masses because they have different numbers of neutrons. • Atoms of an element can differ in the number of neutrons and, therefore, masses.