Name: _____

1. ____ According to the wave-mechanical model of the atom, electrons in an atom
   (1) travel in defined circles
   (2) are most likely found in an excited state
   (3) have a positive charge
   (4) are located in orbitals outside the nucleus

2. ____ What is the total charge of the nucleus of a carbon atom?
   (1) –6   (2) 0   (3) +6   (4) +12

3. ____ When an atom loses one or more electrons, this atom becomes a
   (1) positive ion with a radius smaller than the radius of this atom
   (2) positive ion with a radius larger than the radius of this atom
   (3) negative ion with a radius smaller than the radius of this atom
   (4) negative ion with a radius larger than the radius of this atom

4. ____ Which electron configuration could represent a strontium atom in an excited state?
   (1) 2–8–18–7–1   (3) 2–8–18–8–1
   (2) 2–8–18–7–3   (4) 2–8–18–8–2

5. ____ Which grouping of circles, when considered in order from the top to the bottom, best represents the relative size of the atoms of Li, Na, K, and Rb, respectively?
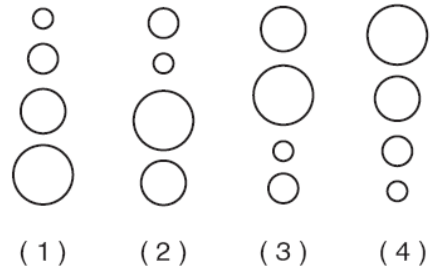
6. ____ What is the total number of neutrons in an atom of $^{57}_{26}Fe$?

   (1) 26   (2) 31   (3) 57   (4) 83

(1)   (2)   (3)   (4)

7. ____ Compared to an electron in the first electron shell of an atom, an electron in the third shell of the same atom has
   (1) less mass   (2) less energy   (3) more mass   (4) more energy

8. ____ An atom in the ground state contains a total of 5 electrons, 5 protons, and 5 neutrons. Which Lewis electron-dot diagram represents this atom?
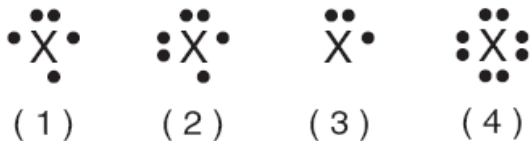
   (1)   (2)   (3)   (4)

9. Determine the percent composition by mass of oxygen in the compound $C_6H_{12}O_6$.

10. ____ What was concluded about the structure of the atom as the result of the gold foil experiment?
    (1) A positively charged nucleus is surrounded by positively charged particles.
    (2) A positively charged nucleus is surrounded by mostly empty space.
    (3) A negatively charged nucleus is surrounded by positively charged particles.
    (4) A negatively charged nucleus is surrounded by mostly empty space.

11. ____ An atom is electrically neutral because the
    (1) number of protons equals the number of electrons
    (2) number of protons equals the number of neutrons
    (3) ratio of the number of neutrons to the number of electrons is 1:1
    (4) ratio of the number of neutrons to the number of protons is 2:1

Name: _____

12. ____ How do the energy and the most probable location of an electron in the third shell of an atom compare to the energy and the most probable location of an electron in the first shell of the same atom?
    (1) In the third shell, an electron has more energy and is closer to the nucleus.
    (2) In the third shell, an electron has more energy and is farther from the nucleus.
    (3) In the third shell, an electron has less energy and is closer to the nucleus.
    (4) In the third shell, an electron has less energy and is farther from the nucleus.

13. ____ An ion of which element has a larger radius than an atom of the same element?
    (1) aluminum   (2) chlorine   (3) magnesium   (4) sodium

14. ____ What is the net charge on an ion that has 9 protons, 11 neutrons, and 10 electrons?
    (1) 1+   (2) 2+   (3) 1–   (4) 2–

15. ____ Which two particles make up most of the mass of a hydrogen-2 atom?
    (1) electron and neutron   (3) proton and neutron
    (2) electron and proton   (4) proton and positron

16. Write an electron configuration for an atom of aluminum-27 in an excited state.

Base your answers to questions 17 through 19 on the information below.
The accepted values for the atomic mass and percent natural abundance of each naturally occurring isotope of silicon are given in the data table below.

Naturally Occurring Isotopes of Silicon

Isotope	Atomic Mass (atomic mass units)	Percent Natural Abundance (%)
Si-28	27.98	92.22
Si-29	28.98	4.69
Si-30	29.97	3.09

17. Determine the total number of neutrons in an atom of Si-29.

18. In the space below, calculate the atomic mass of Si.

19. A scientist calculated the percent natural abundance of Si-30 in a sample to be 3.29%. Determine the percent error for this value.
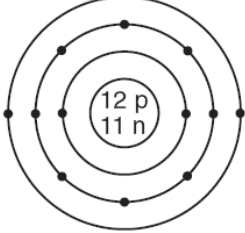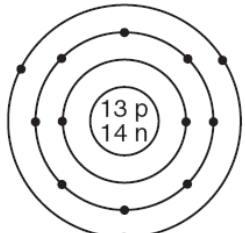
20. ____ Which quantity identifies an element?
    (1) atomic number   (3) total number of neutrons in an atom of the element
    (2) mass number   (4) total number of valence electrons in an atom of the element

21. ____ Which atom in the ground state has a partially filled second electron shell?
    (1) hydrogen atom   (2) lithium atom   (3) potassium atom   (4) sodium atom

22. ____ What is the total charge of the nucleus of a nitrogen atom?
    (1) +5   (2) +2   (3) +7   (4) +14

23. ____ Which value of an element is calculated using both the mass and the relative abundance of each of the naturally occurring isotopes of this element?
    (1) atomic number   (2) atomic mass   (3) half-life   (4) molar volume

Name: _____

24. ____ The mass of 12 protons is approximately equal to
      (1) 1 atomic mass unit   (3) the mass of 1 electron
      (2) 12 atomic mass units   (4) the mass of 12 electrons

25. ____ Which two notations represent different isotopes of the same element?

(1) $^{6}_{4}Be$ and $^{9}_{4}Be$ (3) $^{14}_{7}N$ and $^{14}_{6}C$

(2) $^{7}_{3}Li$ and $^{7}_{3}Li$ (4) $^{32}_{15}P$ and $^{32}_{16}S$

26. ____ What is the gram-formula mass of $Ca_3(PO_4)_2$?
      (1) 248 g/mol   (2) 263 g/mol   (3) 279 g/mol   (4) 310. g/mol

27. ____ When sodium and fluorine combine to produce the compound NaF, the ions formed have the same electron configuration as atoms of
      (1) argon, only   (2) neon, only   (3) both argon and neon   (4) neither argon nor neon

28. Write *one* electron configuration for an atom of silicon in an excited state.

Base your answers to questions 29 through 31 on the information below.

Atomic Diagrams of Magnesium and Aluminum

Key	Element	Lewis Electron-Dot Diagram	Electron-Shell Diagram
• = electron	magnesium	Mg:	12 p 11 n
	aluminum	Al:	13 p 14 n

29. Identify *one* piece of information shown in the electron-shell diagrams that is *not* shown in the Lewis electron-dot diagrams.

30. Determine the mass number of the magnesium atom represented by the electron-shell diagram.

31. Explain why Lewis electron-dot diagrams are generally more suitable than electron-shell diagrams for illustrating chemical bonding.

Name: _____

1. _____ Which two characteristics are associated with metals?
   (1) low first ionization energy and low electronegativity
   (2) low first ionization energy and high electronegativity
   (3) high first ionization energy and low electronegativity
   (4) high first ionization energy and high electronegativity

2. _____ Which element is most chemically similar to chlorine?
   (1) Ar   (2) F   (3) Fr   (4) S

3. _____ At STP, which element is brittle and *not* a conductor of electricity?
   (1) S   (2) K   (3) Na   (4) Ar

Base your answers to questions 4 through 7 on the information below.
The table below lists physical and chemical properties of six elements at standard pressure that correspond to known elements on the Periodic Table. The elements are identified by the code letters, *D, E, G, J, L,* and *Q*.

Properties of Six Elements at Standard Pressure

Element D	Element E	Element G
Density 0.00018 g/cm³	Density 1.82 g/cm³	Density 0.53 g/cm³
Melting point –272°C	Melting point 44°C	Melting point 181°C
Boiling point –269°C	Boiling point 280°C	Boiling point 1347°C
Oxide formula (none)	Oxide formula E_2O_5	Oxide formula G_2O
Element J	**Element L**	**Element Q**
Density 0.0013 g/cm³	Density 0.86 g/cm³	Density 0.97 g/cm³
Melting point –210°C	Melting point 64°C	Melting point 98°C
Boiling point –196°C	Boiling point 774°C	Boiling point 883°C
Oxide formula J_2O_5	Oxide formula L_2O	Oxide formula Q_2O

4. What is the total number of elements in the "Properties of Six Elements at Standard Pressure" table that are solids at STP?

5. An atom of element *G* is in the ground state. What is the total number of valence electrons in this atom?

Letter *Z* corresponds to an element on the Periodic Table other than the six listed elements. Elements *G, Q, L,* and *Z* are in the same group on the Periodic Table, as shown in the diagram below.

G
Q
L
Z

6. Based on the trend in the melting points for elements *G, Q,* and *L* listed in the "Properties of Six Elements at Standard Pressure" table, estimate the melting point of element *Z*, in degrees Celsius.

7. Identify, by code letter, the element that is a noble gas in the "Properties of Six Elements at Standard Pressure" table.

8. _____ Which element is a solid at STP and a good conductor of electricity?
   (1) iodine   (2) mercury   (3) nickel   (4) sulfur

9. _____ Which element has both metallic and nonmetallic properties?
   (1) Rb   (2) Rn   (3) Si   (4) Sr

10. _____ The carbon atoms in graphite and the carbon atoms in diamond have different
   (1) atomic numbers   (2) atomic masses   (3) electronegativities   (4) structural arrangements

Name: _____

11. ____ Atoms of which element have the greatest tendency to gain electrons?
     (1) bromine   (2) chlorine   (3) fluorine   (4) iodine

12. ____ Which statement describes a chemical property of the element magnesium?
     (1) Magnesium is malleable.   (3) Magnesium reacts with an acid.
     (2) Magnesium conducts electricity.   (4) Magnesium has a high boiling point.

13. ____ Which statement explains why sulfur is classified as a Group 16 element?
     (1) A sulfur atom has 6 valence electrons.   (3) Sulfur is a yellow solid at STP.
     (2) A sulfur atom has 16 neutrons.   (4) Sulfur reacts with most metals.

14. ____ How do the atomic radius and metallic properties of sodium compare to the atomic radius and metallic properties of phosphorus?
     (1) Sodium has a larger atomic radius and is more metallic.
     (2) Sodium has a larger atomic radius and is less metallic.
     (3) Sodium has a smaller atomic radius and is more metallic.
     (4) Sodium has a smaller atomic radius and is less metallic.

Base your answers to questions 15 through 17 on the information below.
Elements with atomic numbers 112 and 114 have been produced and their IUPAC names are pending approval. However, an element that would be put between these two elements on the Periodic Table has not yet been produced. If produced, this element will be identified by the symbol Uut until an IUPAC name is approved.

15. In the space provided, draw a
 Lewis electron-dot diagram for an
atom of Uut.

16. Determine the charge of an Uut nucleus. Your response must include
both the numerical value and the sign of the charge.

17. Identify *one* element that would be chemically similar to Uut.

18. ____ Sodium atoms, potassium atoms, and cesium atoms have the same
     (1) atomic radius   (3) total number of protons
     (2) first ionization energy   (4) oxidation state

19. ____ Which statement describes a chemical property of hydrogen gas?
     (1) Hydrogen gas burns in air.   (3) Hydrogen gas has a density of 0.000 09 g/cm^3 at STP.
     (2) Hydrogen gas is colorless.   (4) Hydrogen gas has a boiling point of 20. K at standard pressure.

20. ____ Which element has the greatest density at STP?
     (1) calcium   (2) carbon   (3) chlorine   (4) copper

21. ____ Which list of elements consists of metalloids, only?
     (1) B, Al, Ga   (2) C, N, P   (3) O, S, Se   (4) Si, Ge, As

22. ____ Which general trend is found in Period 2 on the Periodic Table as the elements are considered in order of increasing atomic number?
     (1) decreasing atomic mass   (3) increasing atomic radius
     (2) decreasing electronegativity   (4) increasing first ionization energy

23. Describe *one* chemical property of Group 1 metals that results from the atoms of each metal having only one valence electron.

Name: _____

Base your answers to questions 1 and 2 on the information below.

Ozone gas, O_3, can be used to kill adult insects in storage bins for grain without damaging the grain. The ozone is roduced from oxygen gas, O_2, in portable ozone generators located near the storage bins. The concentrations of ozone used are so low that they do not cause any environmental damage. This use of ozone is safer and more environmentally friendly than a method that used bromomethane, CH_3Br. However, bromomethane was more effective than ozone because CH_3Br killed immature insects as well as adult insects.

1. Determine the total number of moles of CH_3Br in 19 grams of CH_3Br (gram-formula mass = 95 grams/mol).

2. Based on the information in the passage, state *one* advantage of using ozone instead of bromomethane for insect control in grain storage bins.

Given the balanced equation representing a reaction:

$$2CO(g) + O_2(g) \leftrightarrow 2CO_2(g)$$
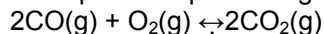
3. ____ What is the mole ratio of $CO(g)$ to $CO_2(g)$ in this reaction?
    (1) 1:1   (2) 1:2   (3) 2:1   (4) 3:2

4. ____ At STP, which sample contains the same number of molecules as 11.2 liters of $CO_2(g)$ at STP?
    (1) 5.6 L of $NO_2(g)$ (2) 7.5 L of $H_2(g)$ (3) 11.2 L of $N_2(g)$ (4) 22.4 L of $CO(g)$

Base your answers to questions 5 through 7 on the information below.

In a laboratory activity, 0.500 mole of $NaOH(s)$ is completely dissolved in distilled water to form 400. milliliters of $NaOH(aq)$. This solution is then used to titrate a solution of $HNO_3(aq)$.

5. Identify the negative ion produced when the $NaOH(s)$ is dissolved in distilled water.

6. In the space provided, calculate the molarity of the $NaOH(aq)$. Your response must include *both* a correct numerical setup and the calculated result.

7. Complete the equation representing this titration reaction by writing the formulas of the products.

$$NaOH(aq) + HNO_3(aq) \rightarrow \text{_____} + \text{_____}$$

Name: _____

8. ____ What is the gram-formula mass of $Ca_3(PO_4)_2$?
    (1) 248 g/mol   (2) 263 g/mol   (3) 279 g/mol   (4) 310. g/mol

9. ____ What is the concentration of $O_2(g)$, in parts per million, in a solution that contains 0.008 gram of $O_2(g)$ dissolved in 1000. grams of $H_2O(l)$?
    (1) 0.8 ppm   (2) 8 ppm   (3) 80 ppm   (4) 800 ppm

Base your answers to questions 10 through 12 on the information below.
Some dry chemicals can be used to put out forest fires. One of these chemicals is $NaHCO_3$. When $NaHCO_3(s)$ is heated, one of the products is $CO_2(g)$, as shown in the balanced equation below.

10. In the space provided, calculate the percent composition by mass of carbon in the product Na_2CO_3.

+--+
| |
| |
| |
| |
| |
| |
+--+

11. Identify the type of chemical reaction represented by this equation.

+----------------------------------+
| |
| |
| |
+----------------------------------+

12. Determine the total number of moles of $CO_2(g)$ produced when 7.0 moles of $NaHCO_3(s)$ is completely reacted.

+--+
| |
| |
| |
| |
| |
+--+

Name: _____

1. ____ What is the name of the polyatomic ion in the compound Na_2O_2?
   (1) hydroxide   (2) oxalate   (3) oxide   (4) peroxide

Given the balanced equation:
$$I + I \rightarrow I_2$$
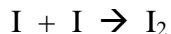
2. ____ Which statement describes the process represented by this equation?
   (1) A bond is formed as energy is absorbed.   (3) A bond is broken as energy is absorbed.
   (2) A bond is formed and energy is released.   (4) A bond is broken and energy is released.

3. ____ An oxygen molecule contains a double bond because the two atoms of oxygen share a total of
   (1) 1 electron   (2) 2 electrons   (3) 3 electrons   (4) 4 electrons

4. ____ Which formula represents lead(II) chromate?
   (1) $PbCrO_4$ (2) $Pb(CrO_4)_2$ (3) Pb_2CrO_4 (4) $Pb_2(CrO_4)_3$

5. ____ Which pair consists of a molecular formula and its corresponding empirical formula?
   (1) C_2H_2 and CH_3CH_3 (2) C_6H_6 and C_2H_2 (3) P_4O_{10} and P_2O_5 (4) SO_2 and SO_3

6. ____ At STP, fluorine is a gas and bromine is a liquid because, compared to fluorine, bromine has
   (1) stronger covalent bonds   (3) weaker covalent bonds
   (2) stronger intermolecular forces   (4) weaker intermolecular forces

7. Determine the percent composition by mass of oxygen in the compound $C_6H_{12}O_6$.

Base your answers to questions 8 and 9 on the information below.
The unbalanced equation below represents the decomposition of potassium chlorate.

8. Balance the equation, using the smallest whole-number coefficients.

$$\_\_\_\_\ KClO_3(s) \rightarrow \_\_\_\_\_\ KCl(s) + \_\_\_\_\ O_2(g)$$

9. Explain, in terms of electronegativity, why a P–Cl bond in a molecule of PCl_5 is more polar than a P–S bond in a molecule of P_2S_5.

---

10. ____ Which polyatomic ion contains the greatest number of oxygen atoms?
    (1) acetate   (2) carbonate   (3) hydroxide   (4) peroxide

11. ____ Which formula represents an ionic compound?
    (1) H_2 (2) CH_4 (3) CH_3OH (4) NH_4Cl

12. ____ What is the total number of different elements present in NH_4NO_3?
    (1) 7   (2) 9   (3) 3   (4) 4

13. ____ At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as
    (1) ionic crystals   (3) nonpolar molecules
    (2) metallic crystals   (4) polar molecules

Name: _____

Base your answers to questions 14 through 16 on the information below.

A hydrate is a compound that has water molecules within its crystal structure. The formula for the hydrate $CuSO_4 \cdot 5H_2O(s)$ shows that there are five moles of water for every one mole of $CuSO_4(s)$. When $CuSO_4 \cdot 5H_2O(s)$ is heated, the water within the crystals is released, as represented by the balanced equation below.

$$CuSO_4 \cdot 5H_2O(s) \leftrightarrow CuSO_4(s) + 5H_2O(g)$$
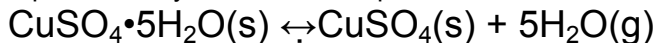
A student first masses an empty crucible (a heat-resistant container). The student then masses the crucible containing a sample of $CuSO_4 \cdot 5H_2O(s)$. The student repeatedly heats and masses the crucible and its contents until the mass is constant. The student's recorded experimental data and calculations are shown below.

14. Identify the total number of significant figures recorded in the calculated mass of $CuSO_4 \cdot 5H_2O(s)$.

15. In the space provided, use the student's data to calculate the percent composition by mass of water in the hydrate.

Data and calculation before heating:

mass of $CuSO_4 \cdot 5H_2O(s)$ and crucible	21.37 g
− mass of crucible	19.24 g
mass of $CuSO_4 \cdot 5H_2O(s)$	2.13 g

Data and calculation after heating to a constant mass:

mass of $CuSO_4(s)$ and crucible	20.61 g
− mass of crucible	19.24 g
mass of $CuSO_4(s)$	1.37 g

Calculation to determine the mass of water:

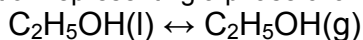|	
mass of $CuSO_4 \cdot 5H_2O(s)$	2.13 g
− mass of $CuSO_4(s)$	1.37 g
mass of $H_2O(g)$	0.76 g

16. Explain why the sample in the crucible must be heated until the constant mass is reached.

17. _____ Which term indicates how strongly an atom attracts the electrons in a chemical bond?
(1) alkalinity   (2) atomic mass   (3) electronegativity   (4) activation energy

18. _____ A solid substance is an excellent conductor of electricity. The chemical bonds in this substance are most likely
(1) ionic, because the valence electrons are shared between atoms
(2) ionic, because the valence electrons are mobile
(3) metallic, because the valence electrons are stationary
(4) metallic, because the valence electrons are mobile

19. _____ Magnesium nitrate contains chemical bonds that are
(1) covalent, only   (3) both covalent and ionic
(2) ionic, only   (4) neither covalent nor ionic

20. Write the empirical formula for the compound C_8H_{18}.

Name:_____

1. ____ A sample composed only of atoms having the same atomic number is classified as
   (1) a compound   (2) a solution   (3) an element   (4) an isomer

2. ____ Which two particles each have a mass approximately equal to one atomic mass unit?
   (1) electron and neutron   (3) proton and electron
   (2) electron and positron   (4) proton and neutron

3. ____ Which substance can be decomposed by chemical means?
   (1) ammonia   (2) oxygen   (3) phosphorus   (4) silicon

4. ____ Which term is defined as a measure of the average kinetic energy of the particles in a sample?
   (1) temperature   (2) pressure   (3) thermal energy   (4) chemical energy

5. ____ A dilute, aqueous potassium nitrate solution is best classified as a
   (1) homogeneous compound   (3) heterogeneous compound
   (2) homogeneous mixture   (4) heterogeneous mixture

Given the equation representing a phase change at equilibrium:
$$C_2H_5OH(l) \leftrightarrow C_2H_5OH(g)$$
6. ____ Which statement is true?
   (1) The forward process proceeds faster than the reverse process.
   (2) The reverse process proceeds faster than the forward process.
   (3) The forward and reverse processes proceed at the same rate.
   (4) The forward and reverse processes both stop.

7. ____ Which particle diagram represents a sample of one compound, only?

Key
⊙ = atom of one element
● = atom of a different element

(1)   (2)   (3)   (4)

8. ____ The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?
   (1) 25°C   (2) 30.°C   (3) 35°C   (4) 40.°C

9. ____ At which Celsius temperature does lead change from a solid to a liquid?
   (1) 874°C   (2) 601°C   (3) 328°C   (4) 0°C

Base your answers to questions 10 through 12 on the information below. A gas sample is held at constant temperature in a closed system. The volume of the gas is changed, which causes the pressure of the gas to change. Volume and pressure data are shown in the table below.

10. On the grid provided, mark an appropriate scale on the axis labeled "Volume (mL)."

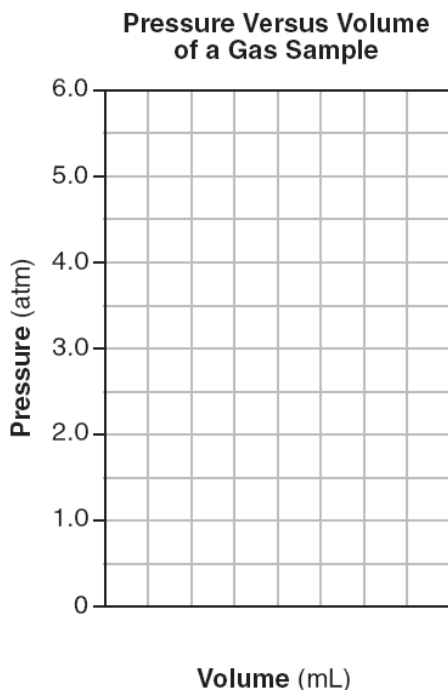11. On the same grid, plot the data from the table. Circle and connect the points.
    Example:

12. Based on your graph, what is the pressure of the gas when the volume of the gas is 200. milliliters?

Volume and Pressure of a Gas Sample

Volume (mL)	Pressure (atm)
1200	0.5
600	1.0
300	2.0
150	4.0
100	6.0

Pressure Versus Volume of a Gas Sample

Regents Review – Matter   Created: April 2008

Name:_____

Base your answers to questions 13 through 15 on the information below.

A 5.00-gram sample of liquid ammonia is originally at 210. K. The diagram of the partial heating curve below represents the vaporization of the sample of ammonia at standard pressure due to the addition of heat. The heat is *not* added at a constant rate.

Some physical constants for ammonia are shown in the data table below.

Some Physical Constants for Ammonia

specific heat capacity of $NH_3(\ell)$	4.71 J/g•K
heat of fusion	332 J/g
heat of vaporization	1370 J/g

Partial Heating Curve for Ammonia

13. In the space provided, calculate the total heat absorbed by the 5.00-gram sample of ammonia during time interval *AB*. Your response must include *both* a correct numerical setup and the calculated result.
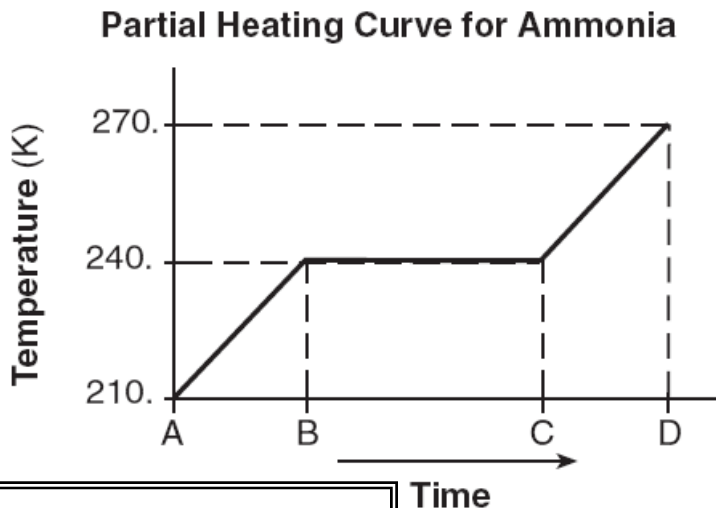
14. Describe what is happening to *both* the potential energy and the average kinetic energy of the molecules in the ammonia sample during time interval *BC*. Your response must include *both* potential energy and average kinetic energy.

15. Determine the total amount of heat required to vaporize this 5.00-gram sample of ammonia at its boiling point.

16. A 1.00-mole sample of neon gas occupies a volume of 24.4 liters at 298 K and 101.3 kilopascals. In the space provided, calculate the density of this sample. Your response must include *both* a correct numerical setup and the calculated result.

Name:_____

Base your answers to questions 17 on the information below.

Propane is a fuel that is sold in rigid, pressurized cylinders. Most of the propane in a cylinder is liquid, with gas in the space above the liquid level. When propane is released from the cylinder, the propane leaves the cylinder as a gas. Propane gas is used as a fuel by mixing it with oxygen in the air and igniting the mixture, as represented by the balanced equation below.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l) + 2219.2 \text{ kJ}$$
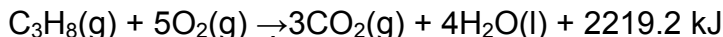
A small amount of methanethiol, which has a distinct odor, is added to the propane to help consumers detect a propane leak. In methanethiol, the odor is caused by the thiol functional group (–SH). Methanethiol, CH3SH, has a structure that is very similar to the structure of methanol.

Key
◯ = propane molecule

17. In the box provided, draw a particle diagram to represent propane in a pressurized cylinder using the key. Your response must include *at least six* molecules of propane in the gas phase and *at least six* molecules of propane in the liquid phase.
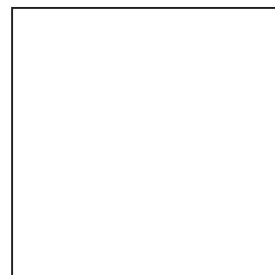
18. ____ Matter that is composed of two or more different elements chemically combined in a fixed proportion is classified as
    (1) a compound   (3) a mixture
    (2) an isotope   (4) a solution

19. ____ Which sample of matter is a single substance?
    (1) air   (2) ammonia gas   (3) hydrochloric acid   (4) salt water

20. ____ A sample of gas is held at constant pressure. Increasing the kelvin temperature of this gas sample causes the average kinetic energy of its molecules to
    (1) decrease and the volume of the gas sample to decrease
    (2) decrease and the volume of the gas sample to increase
    (3) increase and the volume of the gas sample to decrease
    (4) increase and the volume of the gas sample to increase

21. ____ The table below shows mass and volume data for four samples of substances at 298 K and 1 atmosphere. Which two samples could consist of the same substance?
    (1) *A* and *B*   (3) *B* and *C*
    (2) *A* and *C*   (4) *C* and *D*

Masses and Volumes of Four Samples

Sample	Mass (g)	Volume (mL)
A	30.	60.
B	40.	50.
C	45	90.
D	90.	120.

22. ____ At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as
    (1) ionic crystals   (3) nonpolar molecules
    (2) metallic crystals   (4) polar molecules

23. ____ Which kelvin temperature is equal to 56°C?
    (1) –329 K   (3) 217 K
    (2) –217 K   (4) 329 K

24. ____ Which substance can be broken down by a chemical change?
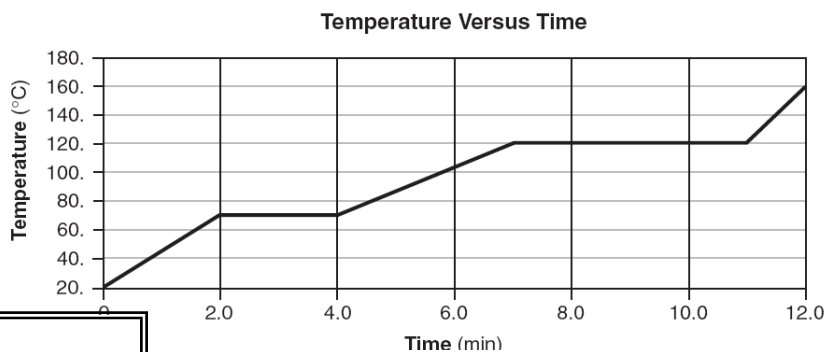   (1) antimony   (2) carbon   (3) hexane   (4) sulfur

25. ____ A rigid cylinder with a movable piston contains a 2.0-liter sample of neon gas at STP. What is the volume of this sample when its temperature is increased to 30.°C while its pressure is decreased to 90. kilopascals?
    (1) 2.5 L   (2) 2.0 L   (3) 1.6 L   (4) 0.22 L

Name:_____

Base your answers to questions 25 through 29 on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.
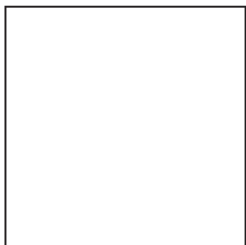
Temperature Versus Time

Temperature (°C) vs *Time (min)*

Y-axis: 20. 40. 60. 80. 100. 120. 140. 160. 180.
X-axis: 2.0 4.0 6.0 8.0 10.0 12.0

Key
◯ = particle of the substance

26. What is the boiling point of this sample? [_____]

27. In the space provided, use the key to draw *at least nine* particles in the box, showing the correct particle arrangement of this sample during the first minute of heating.

28. What is the total time this sample is in the liquid phase, only? [_____]

29. Determine the total amount of heat required to completely melt this sample at its melting point.

[_____]

The table below shows data for the temperature, pressure, and volume of four gas samples.

30. ____ Which two gas samples have the same total number of molecules?
   (1) *A* and *B*   (3) *B* and *C*
   (2) *A* and *C*   (4) *B* and *D*

31. ____ At which temperature is the vapor pressure of ethanol equal to the vapor pressure of propanone at 35°C?
   (1) 35°C   (2) 60.°C   (3) 82°C   (4) 95°C

Data for Four Gas Samples

Gas Sample	Temperature (K)	Pressure (atm)	Volume (mL)
A	100.	2	400.
B	200.	2	200.
C	100.	2	400.
D	200.	4	200.

Base your answers to questions 32 through 34 on the information to the right. A 100.0-gram sample of NaCl(s) has an initial temperature of 0°C. A chemist measures the temperature of the sample as it is heated. Heat is *not* added at a constant rate. The heating curve for the sample is shown below.

32. Determine the temperature range over which the entire NaCl sample is a liquid. [_____]

33. Identify *one* line segment on the curve where the average kinetic energy of the particles of the NaCl sample is changing.

[_____]

34. Identify *one* line segment on the curve where the NaCl sample is in a single phase and capable of conducting electricity.

[_____]

Heating Curve for Sodium Chloride

Temperature (°C) vs *Time*

Y-axis marks: 0, 801, 1465
Points labeled: A, B, C, D, E

Name:_____

Base your answers to questions 35 and 36 on the information below.

A student performed an experiment to determine the total amount of energy stored in a peanut. The accepted value for the energy content of a peanut is 30.2 kilojoules per gram. The student measured 100.0 grams of water into a metal can and placed the can on a ring stand, as shown in the diagram below. The peanut was attached to a wire suspended under the can. The initial temperature of the water was recorded as 22.0°C. The peanut was ignited and allowed to burn. When the peanut finished burning, the final water temperature was recorded as 57.0°C. The student's experimental value for the energy content of this peanut was 25.9 kilojoules per gram.
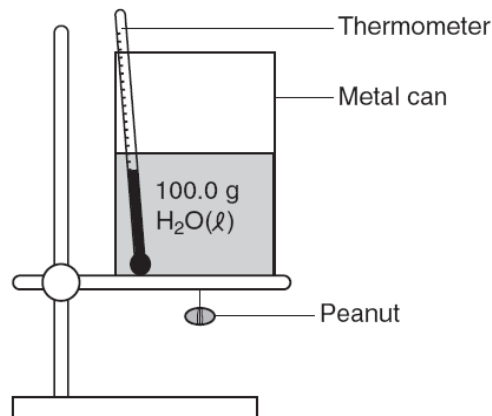
35. In the space provided, calculate the total amount of heat absorbed by the water. Your response must include *both* a correct numerical setup and the calculated result.

36. Determine the student's percent error for the energy content of this peanut.

Base your answers to questions 37 and 38 on the information below.

In an investigation, a dripless wax candle is massed and then lighted. As the candle burns, a small amount of liquid wax forms near the flame. After 10 minutes, the candle's flame is extinguished and the candle is allowed to cool. The cooled candle is massed.

Boiling Point Versus Molar Mass of Some Alkanes
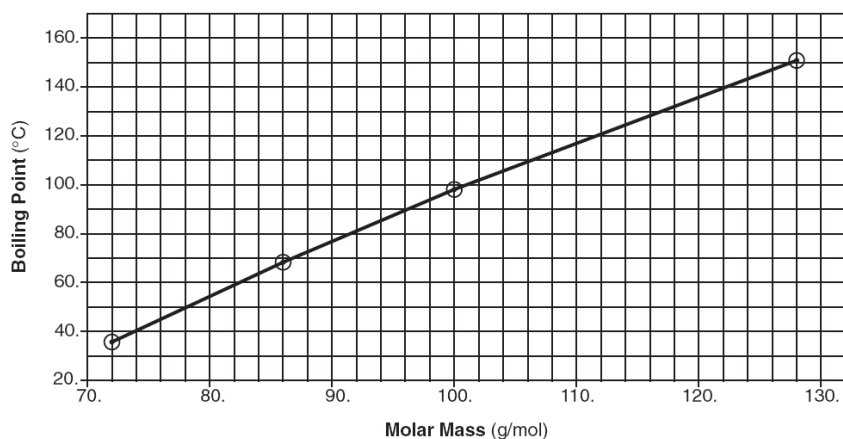
37. Identify *one* physical change that takes place in this investigation.

38. State *one* observation that indicates a chemical change has occurred in this investigation.

Name: _____

1. ____ A 3.0 M HCl(aq) solution contains a total of
       (1) 3.0 grams of HCl per liter of water   (3) 3.0 moles of HCl per liter of solution
       (2) 3.0 grams of HCl per mole of solution   (4) 3.0 moles of HCl per mole of water

2. ____ A dilute, aqueous potassium nitrate solution is best classified as a
       (1) homogeneous compound   (3) heterogeneous compound
       (2) homogeneous mixture   (4) heterogeneous mixture

Base your answers to questions 3 through 5 on the information below.
Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O_2, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.

Solubility of Oxygen in Water Versus Temperature

Mass of Dissolved O_2 (mg) in 1000. g of Water versus *Temperature (°C)*
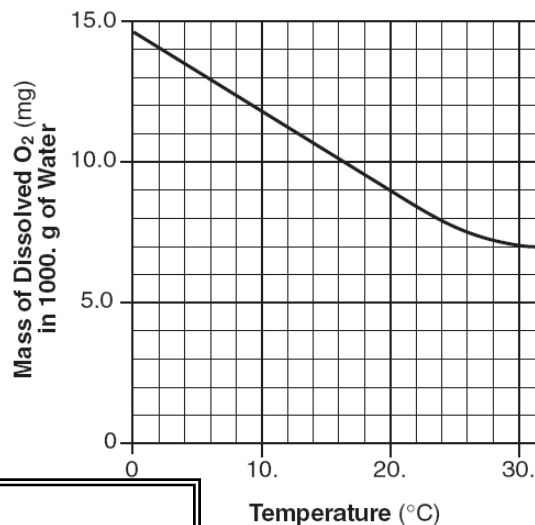
3. A student determines that 8.2 milligrams of oxygen is dissolved in a 1000.-gram sample of water at 15°C and 1.0 atmosphere. In terms of saturation, what type of solution is this sample?

4. Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water.

5. An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. In the space provided, calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result.

6. ____ Which statement must be true when solution equilibrium occurs?
       (1) The solution is at STP.
       (2) The solution is supersaturated.
       (3) The concentration of the solution remains constant.
       (4) The masses of the dissolved solute and the undissolved solute are equal.

7. ____ Which liquid has the highest vapor pressure at 75°C?
       (1) ethanoic acid   (2) ethanol   (3) propanone   (4) water

8. ____ An unsaturated solution is formed when 80. grams of a salt is dissolved in 100. grams of water at 40.°C. This salt could be
       (1) KCl   (2) KNO_3 (3) NaCl   (4) $NaNO_3$

9. ____ Which barium salt is *insoluble* in water?
       (1) $BaCO_3$ (2) $BaCl_2$ (3) $Ba(ClO_4)_2$ (4) $Ba(NO_3)_2$

Name: _____

10. ____ Which unit can be used to express solution concentration?
    (1) J/mol   (2) L/mol   (3) mol/L   (4) mol/s

11. ____ Under which conditions of temperature and pressure is a gas most soluble in water?
    (1) high temperature and low pressure   (3) low temperature and low pressure
    (2) high temperature and high pressure   (4) low temperature and high pressure

12. ____ As water is added to a 0.10 M NaCl aqueous solution, the conductivity of the resulting solution
    (1) decreases because the concentration of ions decreases
    (2) decreases, but the concentration of ions remains the same
    (3) increases because the concentration of ions decreases
    (4) increases, but the concentration of ions remains the same

Base your answers to questions 13 and 14 on the information below.
A solution is made by completely dissolving 90. grams of $KNO_3(s)$ in 100. grams of water in a beaker. The temperature of this solution is 65°C.

13. Describe the effect on the solubility of $KNO_3(s)$ in this solution when the pressure on the solution increases.

14. Determine the total mass of $KNO_3(s)$ that settles to the bottom of the beaker when the original solution is cooled to 15°C.

Name: _____

1. ____ A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?
(1) a zinc strip and 1.0 M HCl(aq)   (3) zinc powder and 1.0 M HCl(aq)
(2) a zinc strip and 3.0 M HCl(aq)   (4) zinc powder and 3.0 M HCl(aq)

2. ____ For a given reaction, adding a catalyst increases the rate of the reaction by
(1) providing an alternate reaction pathway that has a higher activation energy
(2) providing an alternate reaction pathway that has a lower activation energy
(3) using the same reaction pathway and increasing the activation energy
(4) using the same reaction pathway and decreasing the activation energy

3. ____ Which reaction releases the greatest amount of energy per 2 moles of product?
(1) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
(2) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
(3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
(4) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

4. ____ Which changes occur when Pt^{2+} is reduced?
(1) The Pt^{2+} gains electrons and its oxidation number increases.
(2) The Pt^{2+} gains electrons and its oxidation number decreases.
(3) The Pt^{2+} loses electrons and its oxidation number increases.
(4) The Pt^{2+} loses electrons and its oxidation number decreases.

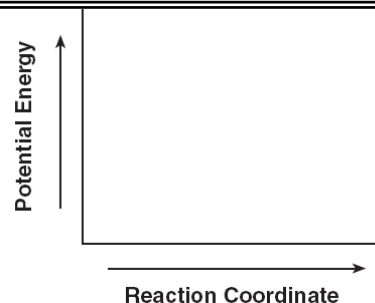Given the equation representing a reaction at equilibrium:
$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + energy$$
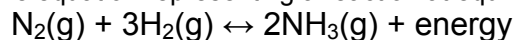
5. ____ Which change causes the equilibrium to shift to the right?
(1) decreasing the concentration of $H_2(g)$ (3) increasing the concentration of $N_2(g)$
(2) decreasing the pressure   (4) increasing the temperature

6. Explain, in terms of collision theory, why the rate of a chemical reaction increases with an increase in temperature.
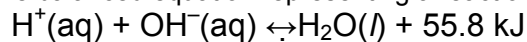
7. On the diagram provided, draw a potential energy diagram for this reaction.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) + 2219.2 \ kJ$$
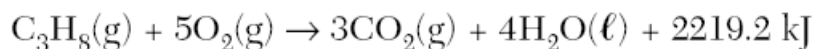
8. Determine the total amount of energy released when 2.50 moles of propane is completely reacted with oxygen.

Potential Energy

Reaction Coordinate

Given the balanced equation representing a reaction:
$$H^+(aq) + OH^-(aq) \leftrightarrow H_2O(l) + 55.8 \ kJ$$

9. ____ In this reaction there is conservation of
(1) mass, only   (3) mass and energy, only
(2) mass and charge, only   (4) mass, charge, and energy

Name: _____

10. ____ Which statement must be true when solution equilibrium occurs?
    (1) The solution is at STP.
    (2) The solution is supersaturated.
    (3) The concentration of the solution remains constant.
    (4) The masses of the dissolved solute and the undissolved solute are equal.
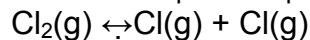
Given the balanced equation representing a reaction:
$$Cl_2(g) \leftrightarrow Cl(g) + Cl(g)$$
11. ____ What occurs during this change?
    (1) Energy is absorbed and a bond is broken.   (3) Energy is released and a bond is broken.
    (2) Energy is absorbed and a bond is formed.   (4) Energy is released and a bond is formed.
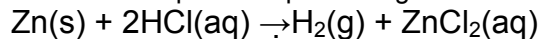
Given the balanced equation representing a reaction:
$$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$
12. ____ Which set of reaction conditions produces $H_2(g)$ at the fastest rate?
    (1) a 1.0-g lump of Zn(s) in 50. mL of 0.5 M HCl(aq) at 20.°C
    (2) a 1.0-g lump of Zn(s) in 50. mL of 0.5 M HCl(aq) at 30.°C
    (3) 1.0 g of powdered Zn(s) in 50. mL of 1.0 M HCl(aq) at 20.°C
    (4) 1.0 g of powdered Zn(s) in 50. mL of 1.0 M HCl(aq) at 30.°C

Base your answers to questions 13 through 15 on the reaction represented by the balanced equation below.

$$2H_2(g) + O_2(g) \leftrightarrow 2H_2O(l) + 571.6 \text{ kJ}$$
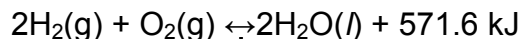
13. Identify the information in this equation that indicates the reaction is exothermic.
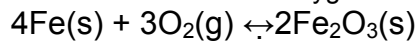
14. On the axes provided, draw a potential energy diagram
for the reaction represented by this equation.
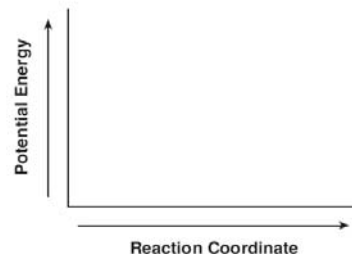
15. Explain why the entropy of the system *decreases* as the reaction proceeds.

Reaction Coordinate

Base your answers to questions 16 through 18 on the information below.
Rust on an automobile door contains $Fe_2O_3(s)$. The balanced equation representing one of the reactions between iron in the door of the automobile and oxygen in the atmosphere is given below.
$$4Fe(s) + 3O_2(g) \leftrightarrow 2Fe_2O_3(s)$$
16. Identify the type of chemical reaction represented by this equation.

17. Determine the gram-formula mass of the product of this reaction.

18. Write the IUPAC name for Fe_2O_3.

19. ____ Which equation shows conservation of atoms?
    (1) $H_2 + O_2 \rightarrow H_2O$ (3) $2H_2 + O_2 \rightarrow 2H_2O$
    (2) $H_2 + O_2 \rightarrow 2H_2O$ (4) $2H_2 + 2O_2 \rightarrow 2H_2O$

Given the equation representing a system at equilibrium:
20. ____ At which temperature does this equilibrium exist at 101.3 kilopascals?
   (1) 0 K   (2) 0°C   (3) 32 K   (4) 273°C

Name: _____

Base your answers to questions 21 and 22 on the information below.

The equilibrium equation below is related to the manufacture of a bleaching solution. In this equation, $Cl^-(aq)$ means that chloride ions are surrounded by water molecules.

$$Cl_2(g) + 2OH–(aq) \leftrightarrow OCl^-(aq) + Cl^-(aq) + H_2O(l)$$

21. Use the key to draw *two* water molecules in the box, showing the correct orientation of each water molecule toward the chloride ion.
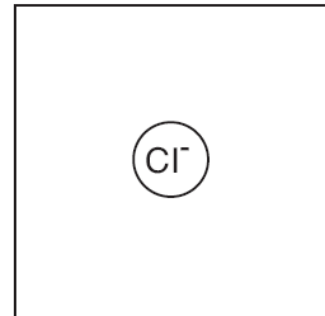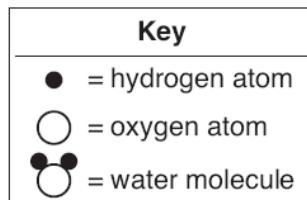
22. Explain, in terms of collision theory, why increasing the concentration of $Cl_2(g)$ increases the concentration of OCl^- (aq) in this equilibrium system.

Key	
●	= hydrogen atom
○	= oxygen atom
(water molecule symbol)	= water molecule

Cl^-

23. ____ Which term refers to the difference between the potential energy of the products and the potential energy of the reactants for any chemical change?
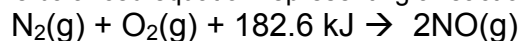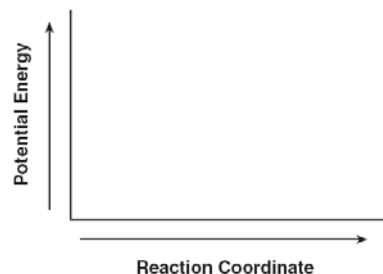(1) heat of deposition   (2) heat of fusion   (3) heat of reaction   (4) heat of vaporization

Given the balanced equation representing a reaction:

$$N_2(g) + O_2(g) + 182.6 \text{ kJ} \rightarrow 2NO(g)$$

On the labeled axes, draw a potential energy diagram for this reaction.

Potential Energy

Reaction Coordinate

Base your answers to questions 14 and 25 on the information below.

A beaker contains 100.0 milliliters of a dilute aqueous solution of ethanoic acid at equilibrium. The equation below represents this system.

$$HC_2H_3O_2(aq) \rightleftharpoons H^+(aq) + C_2H_3O_2^-(aq)$$
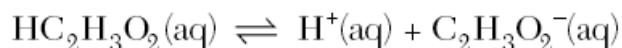
24. Compare the rate of the forward reaction to the rate of the reverse reaction for this system.

25. Describe what happens to the concentration of H+(aq) when 10 drops of concentrated $HC_2H_3O_2(aq)$ are added to this system.

Base your answers to questions 26 through 28 on the information below.

"Hand Blasters" is a toy that consists of a set of two ceramic balls, each coated with a mixture of sulfur and potassium chlorate, KClO3. When the two balls are struck together, a loud popping noise is produced as sulfur and potassium chlorate react with each other.

26. Balance the equation for the "Hand Blaster" reaction, using the smallest whole-number coefficients.

_____ $S(s)$ + _____ $KClO_3(s) \rightarrow$ _____ $SO_2(g)$ + _____ $KCl(s)$ + energy
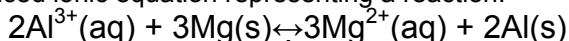
27. Identify *one* source of the activation energy for this reaction

28. Determine the oxidation number of chlorine in the reactant that contains chlorine.

Name:_____

1. ____ Which changes occur when Pt^{2+} is reduced?
   (1) The Pt^{2+} gains electrons and its oxidation number increases.
   (2) The Pt^{2+} gains electrons and its oxidation number decreases.
   (3) The Pt^{2+} loses electrons and its oxidation number increases.
   (4) The Pt^{2+} loses electrons and its oxidation number decreases.

2. ____ Which balanced equation represents an oxidation-reduction reaction?
   (1) $BaCl_2 + Na_2SO_4 \leftrightarrow BaSO_4 + 2NaCl$
   (2) $C + H_2O \leftrightarrow CO + H_2$
   (3) $CaCO_3 \leftrightarrow CaO + CO_2$
   (4) $Mg(OH)_2 + 2HNO_3 \leftrightarrow Mg(NO_3)_2 + 2H_2O$

3. ____ Which energy conversion occurs during the operation of a voltaic cell?
   (1) Chemical energy is spontaneously converted to electrical energy.
   (2) Chemical energy is converted to electrical energy only when an external power source is provided.
   (3) Electrical energy is spontaneously converted to chemical energy.
   (4) Electrical energy is converted to chemical energy only when an external power source is provided.

4. ____ What is the total number of electrons in a Mg^{2+} ion?
   (1) 10   (2) 12   (3) 14   (4) 24

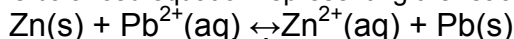Given the balanced ionic equation representing a reaction:
$$2Al^{3+}(aq) + 3Mg(s) \leftrightarrow 3Mg^{2+}(aq) + 2Al(s)$$
5. ____ In this reaction, electrons are transferred from
   (1) Al to Mg^{2+} (2) Al^{3+} to Mg   (3) Mg to Al^{3+} (4) Mg^{2+} to Al

The unbalanced equation below represents the decomposition of potassium chlorate.
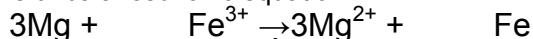$$KClO_3(s) \leftrightarrow KCl(s) + O_2(g)$$
6. Determine the oxidation number of chlorine in the reactant.

7. ____ What is the net charge on an ion that has 9 protons, 11 neutrons, and 10 electrons?
   (1) 1+   (2) 2+   (3) 1–   (4) 2–

8. ____ Which group on the Periodic Table of the Elements contains elements that react with oxygen to form compounds with the general formula X_2O?
   (1) Group 1   (2) Group 2   (3) Group 14   (4) Group 18

Given the balanced equation representing the reaction occurring in a voltaic cell:
$$Zn(s) + Pb^{2+}(aq) \leftrightarrow Zn^{2+}(aq) + Pb(s)$$
9. ____ In the completed external circuit, the electrons flow from
   (1) Pb(s) to Zn(s)   (3) Zn(s) to Pb(s)
   (2) $Pb^{2+}(aq)$ to $Zn^{2+}(aq)$ (4) $Zn^{2+}(aq)$ to $Pb^{2+}(aq)$

10. ____ Which balanced equation represents a redox reaction?
   (1) $CuCO_3(s) \leftrightarrow CuO(s) + CO_2(g)$ (3) $AgNO_3(aq) + KCl(aq) \leftrightarrow AgCl(s) + KNO_3(aq)$
   (2) $2KClO_3(s) \leftrightarrow 2KCl(s) + 3O_2(g)$ (4) $H_2SO_4(aq) + 2KOH(aq) \leftrightarrow K_2SO_4(aq) + 2H_2O(l)$

Given the unbalanced ionic equation:
$$3Mg + \underline{\quad} Fe^{3+} \rightarrow 3Mg^{2+} + \underline{\quad} Fe$$
11. ____ When this equation is balanced, both Fe^{3+} and Fe have a coefficient of
   (1) 1, because a total of 6 electrons is transferred   (3) 1, because a total of 3 electrons is transferred
   (2) 2, because a total of 6 electrons is transferred   (4) 2, because a total of 3 electrons is transferred

Name:_____

A student collects the materials and equipment below to construct a voltaic cell.
- two 250-mL beakers
- wire and a switch
- one strip of magnesium
- one strip of copper
- 125 mL of 0.20 M Mg(NO3)2(aq)
- 125 mL of 0.20 M Cu(NO3)2(aq)

12. ____ Which additional item is required for the construction of the voltaic cell?
(1) an anode   (2) a battery   (3) a cathode   (4) a salt bridge

13. What is the oxidation number of nitrogen in NO(g)?

Base your answers to questions 14 and 15 on the information below.
Electroplating is an electrolytic process used to coat metal objects with a more expensive and less reactive metal. The diagram below shows an electroplating cell that includes a battery connected to a silver bar and a metal spoon. The bar and spoon are submerged in $AgNO_3$(aq).

14. Explain why $AgNO_3$ is a better choice than AgCl for use in this electrolytic process.

15. Explain the purpose of the battery in this cell.

An Electroplating Cell
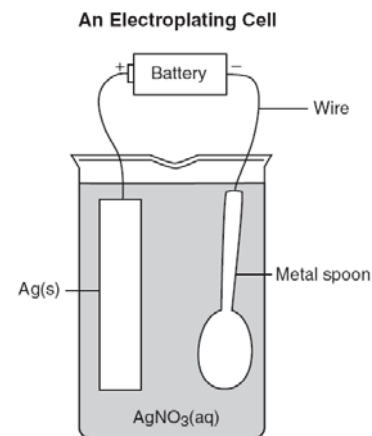
16. ____ In a redox reaction, the total number of electrons lost is
(1) less than the total number of electrons gained   (3) equal to the total number of electrons gained
(2) greater than the total number of electrons gained   (4) equal to the total number of protons gained

17. ____ Which energy conversion occurs in a voltaic cell?
(1) chemical energy to electrical energy   (3) electrical energy to chemical energy
(2) chemical energy to nuclear energy   (4) nuclear energy to electrical energy

18. ____ Which metal is more active than Ni and *less* active than Zn?
(1) Cu   (2) Cr   (3) Mg   (4) Pb

19. ____ In which compound is the ratio of metal ions to nonmetal ions 1 to 2?
(1) calcium bromide   (3) calcium phosphide
(2) calcium oxide   (4) calcium sulfide

20. ____ Reduction occurs at the cathode in
(1) electrolytic cells, only   (3) both electrolytic cells and voltaic cells
(2) voltaic cells, only   (4) neither electrolytic cells nor voltaic cells

Name: _____

1. ____ An Arrhenius base yields which ion as the only negative ion in an aqueous solution?
   (1) hydride ion   (2) hydrogen ion   (3) hydronium ion   (4) hydroxide ion

2. ____ According to one acid-base theory, a water molecule acts as an acid when the water molecule
   (1) accepts an H+   (2) accepts an OH–   (3) donates an H+   (4) donates an OH–

3. ____ Which two formulas represent Arrhenius acids?
   (1) CH_3COOH and CH_3CH_2OH (3) $KHCO_3$ and $KHSO_4$
   (2) $HC_2H_3O_2$ and H_3PO_4 (4) NaSCN and $Na_2S_2O_3$

Information related to a titration experiment is given in the balanced equation and table below.

$$H_2SO_4(aq) + 2KOH(aq) \leftrightarrow K_2SO_4(aq) + 2H_2O(l)$$
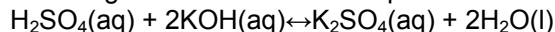
Titration Experiment Results

volume of $H_2SO_4(aq)$ used	12.0 mL
concentration of $H_2SO_4(aq)$	?
volume of KOH(aq) used	36.0 mL
concentration of KOH(aq)	0.16 M

4. _____ Based on the equation and the titration results, what is the concentration of the $H_2SO_4(aq)$?
   (1) 0.12 M   (2) 0.16 M   (3) 0.24 M   (4) 0.96 M

Base your answers to questions 5 and 6 on the information below.

Sulfur dioxide, SO_2, is one gas produced when fossil fuels are burned. When this gas reacts with water in the atmosphere, an acid is produced forming acid rain. The pH of the water in a lake changes when acid rain collects in the lake. Two samples of the same rainwater are tested using two indicators. Methyl orange is yellow in one sample of this rainwater. Litmus is red in the other sample of this rainwater.

5. Identify a possible pH value for the rainwater that was tested. _____

6. Write the formula for *one* substance that can neutralize the lake water affected by acid rain. _____

7. ____ Which formula represents a hydronium ion?
   (1) H_3O+ (2) NH_4^+ (3) OH^- (4) HCO_3^-

8. ____ Which compound is an Arrhenius acid?
   (1) H_2SO_4 (2) KCl   (3) NaOH   (4) NH_3

The table below shows the color of the indicators methyl orange and litmus in two samples of the same solution.

Results of Acid-Base Indicator Tests

Indicator	Color Result from the Indicator Test
methyl orange	yellow
litmus	red

9. ____ Which pH value is consistent with the indicator results?
   (1) 1   (2) 5   (3) 3   (4) 10

10. ____ What is the pH of a solution that has a hydronium ion concentration 100 times greater than a solution with a pH of 4?
    (1) 5   (2) 2   (3) 3   (4) 6

Name: _____

11. What color is bromcresol green after it is added to a sample of NaOH(aq)? _____

12. ____ Which substance is an Arrhenius acid?
 (1) $Ba(OH)_2$ (2) CH_3COOCH_3 (3) H_3PO_4 (4) NaCl

13. ____ Which compound releases hydroxide ions in an aqueous solution?
 (1) CH_3COOH (2) CH_3OH (3) HCl (4) KOH

14. ____ What are the products of a reaction between KOH(aq) and HCl(aq)?
 (1) H_2 and KClO (2) H_2O and KCl (3) KH and HClO (4) KOH and HCl

15. ____ Which volume of 0.10 M NaOH(aq) exactly neutralizes 15.0 milliliters of 0.20 M HNO_3(aq)?
 (1) 1.5 mL (2) 7.5 mL (3) 3.0 mL (4) 30. mL

16. ____ Which indicator, when added to a solution, changes color from yellow to blue as the pH of the solution is changed from 5.5 to 8.0?
 (1) bromcresol green (2) bromthymol blue (3) litmus (4) methyl orange

17. ____ The pH of an aqueous solution changes from 4 to 3 when the hydrogen ion concentration in the solution is

 (1) decreased by a factor of $\dfrac{3}{4}$ (3) increased by a factor of $\dfrac{4}{3}$

 (2) decreased by a factor of 10 (4) increased by a factor of 10

Base your answers to questions 18 through 20 on the information below.
A laboratory worker filled a bottle with a hydrochloric acid solution. Another bottle was filled with methanol, while a third bottle was filled with a sodium hydroxide solution. However, the worker neglected to label each bottle. After a few days, the worker could not remember which liquid was in each bottle. The worker needed to identify the liquid in each bottle. The bottles were labeled *A*, *B*, and *C*. Using materials found in the lab (indicators, conductivity apparatus, and pieces of Mg metal), the worker tested samples of liquid from each bottle. The test results are shown in the table below.

Table of Tests and Results

Test	Test Results		
	Bottle A	Bottle B	Bottle C
methyl orange indicator	yellow	yellow	yellow
bromthymol blue indicator	blue	green	yellow
electrical conductivity	conductor	nonconductor	conductor
reactivity with Mg metal	no reaction	no reaction	reaction

18. Using the test results, state how the worker differentiated the bottle that contained methanol from the other two bottles.

19. The worker concluded that bottle *C* contained hydrochloric acid. Identify *one* test and state the corresponding test result that supports this conclusion.

20. Explain, in terms of pH, why the methyl orange indicator test results were the same for each of the three liquids.

Name: _____

1. ____ What is the total number of carbon atoms in a molecule of ethanoic acid?
   (1) 1   (2) 2   (3) 3   (4) 4

Given the formulas for two compounds:

2. ____ These compounds differ in
   (1) gram-formula mass   (3) percent composition by mass
   (2) molecular formula   (4) physical properties at STP

3. ____ A double carbon-carbon bond is found in a molecule of
   (1) pentane   (2) pentene   (3) pentyne   (4) pentanol

4. ____ Which compound is an unsaturated hydrocarbon?
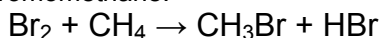   (1) hexanal   (2) hexane   (3) hexanoic acid   (4) hexyne
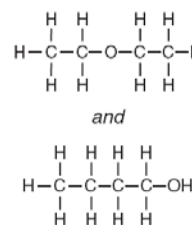
5. ____ The organic compound represented by the condensed structural formula $CH_3CH_2CH_2CHO$ is classified as an
   (1) alcohol   (2) aldehyde   (3) ester   (4) ether

6. In the space provided, draw a structural formula for a molecule of methanethiol.

Given the balanced equation for producing bromomethane:
$$Br_2 + CH_4 \rightarrow CH_3Br + HBr$$
Identify the type of organic reaction shown.

7. ____ A molecule of butane and a molecule of 2-butene both have the same total number of
   (1) carbon atoms   (2) hydrogen atoms   (3) single bonds   (4) double bonds

8. ____ Which general formula represents the homologous series of hydrocarbons that includes the compound 1-heptyne?
   (1) C_nH_{2n-6} (2) C_nH_{2n-2} (3) C_nH_{2n} (4) C_nH_{2n+2}

9. ____ Which two compounds are isomers of each other?
   (1) CH_3CH_2COOH and $CH_3COOCH_2CH_3$
   (2) CH_3CH_2CHO and CH_3COCH_3
   (3) $CH_3CHBrCH_3$ and $CH_2BrCHBrCH_3$
   (4) $CH_3CHOHCH_3$ and $CH_3CHOHCH_2OH$

10. ____ Which formula represents an unsaturated hydrocarbon?
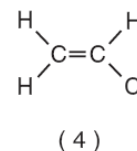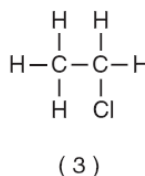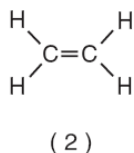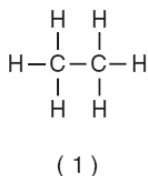
11. ____ A compound has a molar mass of 90. grams per mole and the empirical formula CH_2O. What is the molecular formula of this compound?
   (1) CH_2O (2) $C_2H_4O_2$ (3) $C_3H_6O_3$ (4) $C_4H_8O_4$

Given the formula of a substance:
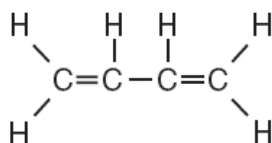
12. ____ What is the total number of shared electrons in a molecule of this substance?
   (1) 22   (2) 11   (3) 9   (4) 6

Regents review – Organic Chemistry   1-1   Created: April 2008

Name: _____

Base your answers to questions 13 through 15 on the information below.
The incomplete equation below represents an esterification reaction. The alcohol
reactant is represented by X.

$$H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\overset{\overset{O}{\|}}{C}-OH \;+\; X \;\xrightarrow{catalyst}\; H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\overset{\overset{O}{\|}}{C}-O-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-H \;+\; H_2O$$
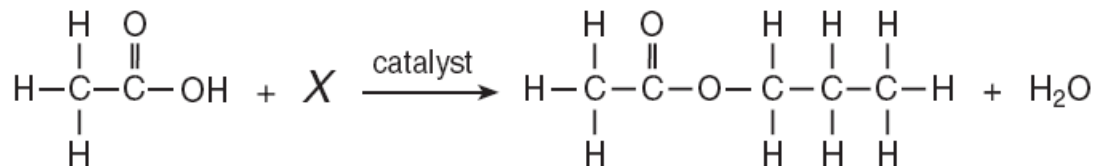
13. On the structural formula,
circle the acid functional group, only.

$$H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\overset{\overset{O}{\|}}{C}-OH$$
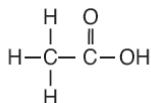
14. Write an IUPAC name for the reactant represented by its structural formula in this equation.

15. In the space provided, draw the structural formula
for the alcohol represented by X.

16. ____ Which formula represents an alkene?
(1) C_2H_6 (2) C_3H_6 (3) C_4H_{10} (4) C_5H_{12}

17. ____ What is the total number of pairs of electrons shared between the carbon atom and the oxygen atom in a
molecule of methanal?
(1) 1   (2) 2   (3) 3   (4) 4

18. ____ Which compound is a saturated hydrocarbon?
(1) CH_2CH_2 (2) CH_3CH_3 (3) CH_3CHO (4) CH_3CH_2OH

19. ____ A molecule of a compound contains a total of 10 hydrogen atoms and has the general formula C_nH_{2n+2}. Which
prefix is used in the name of this compound?
(1) but-   (2) dec-   (3) oct-   (4) pent-

20. Write the empirical formula for the compound C_8H_{18}.

A beaker contains 100.0 milliliters of a dilute aqueous solution of ethanoic acid at equilibrium. The equation below
represents this system.
$$HC_2H_3O_2(aq) \rightleftharpoons H^+(aq) + C_2H_3O_2^-(aq)$$

21. In the space provided,
draw a structural formula for
ethanoic acid.

Name: _____

Base your answers to questions 22 through 24 on the information below.

The compound 1,2-ethanediol can be mixed with water. This mixture is added to automobile radiators as an engine coolant. The cooling system of a small van contains 6690 grams of 1,2-ethanediol. Some properties of water and 1,2-ethanediol are given in the table below.

Properties of Water and 1,2-ethanediol

Property	Water (H_2O)	1,2-ethanediol (CH_2OHCH_2OH)
gram-formula mass (g/mol)	18.0	62.0
boiling point at standard pressure (°C)	100.0	197.2

22. Identify the class of organic compounds to which 1,2-ethanediol belongs.

23. State, in terms of molecular polarity, why 1,2-ethanediol is soluble in water.

24. In the space provided, calculate the total number of moles of 1, 2-ethanediol in the small van's cooling system. Your response must include *both* a correct numerical setup and the calculated result.

Base your answers to questions 25 and 26 on the information below.

The graph below shows the relationship between boiling point and molar mass at standard pressure for pentane, hexane, heptane, and nonane.

25. Octane has a molar mass of 114 grams per mole. According to this graph, what is the boiling point of octane at standard pressure?

Boiling Point Versus Molar Mass of Some Alkanes

26. State the relationship between molar mass and the strength of intermolecular forces for the selected alkanes.

Name: _____

1. ____ Which list of radioisotopes contains an alpha emitter, a beta emitter, and a positron emitter?
   (1) C-14, N-16, P-32　　　　　　　　　　(3) Kr-85, Ne-19, Rn-222
   (2) Cs-137, Fr-220, Tc-99　　　　　　　　(4) Pu-239, Th-232, U-238

2. ____ Which nuclear decay emission consists of energy, only?
   (1) alpha particle　　　　(2) beta particle　　　　(3) gamma radiation　　　　(4) positron

3. ____ Which balanced equation represents nuclear fusion?

   (1) $^{1}_{0}n$ + $^{235}_{92}U$ → $^{142}_{56}Ba$ + $^{91}_{36}Kr$ + $3^{1}_{0}n$

   (2) $^{226}_{88}Ra$ → $^{222}_{86}Rn$ + $^{4}_{2}He$

   (3) $^{6}_{3}Li$ + $^{1}_{0}n$ → $^{3}_{1}H$ + $^{4}_{2}He$

   (4) $^{2}_{1}H$ + $^{3}_{1}H$ → $^{4}_{2}He$ + $^{1}_{0}n$

4. ____ The energy released by a nuclear reaction results primarily from the
   (1) breaking of bonds between atoms　　　(3) conversion of mass into energy
   (2) formation of bonds between atoms　　　(4) conversion of energy into mass

5. ____ Which radioisotope is used in medicine to treat thyroid disorders?
   (1) cobalt-60　　　　(2) iodine-131　　　　(3) phosphorus-32　　　　(4) uranium-238

6. Complete the nuclear equation. Include the symbol, atomic number, and mass number for the missing particle.

   $$^{42}_{19}K \rightarrow\ ^{0}_{-1}e\ +\ \underline{\hspace{3cm}}$$

Base your answers to questions 7 through 9 on the information below.
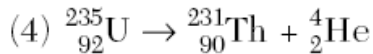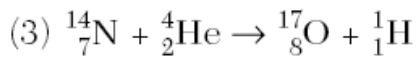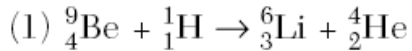In living organisms, the ratio of the naturally occurring isotopes of carbon, C-12 to C-13 to C-14, is fairly consistent. When an organism such as a woolly mammoth died, it stopped taking in carbon, and the amount of C-14 present in the mammoth began to decrease. For example, one fossil of a woolly mammoth is found to have $\frac{1}{32}$ of the amount of C-14 found in a living organism.

7. Identify the type of nuclear reaction that caused the amount of C-14 in the woolly mammoth to *decrease* after the organism died.

8. Determine the total time that has elapsed since this woolly mammoth died.

9. State, in terms of subatomic particles, how an atom of C-13 is different from an atom of C-12.

10. ____ What is the decay mode of ^{37}K?
    (1) β–　　　　(2) β+　　　　(3) γ　　　　(4) α

11. ____ Which nuclear emission has the greatest penetrating power?
    (1) alpha particle　　　　(2) beta particle　　　　(3) gamma radiation　　　　(4) positron

12. ____ What is the mass number of an alpha particle?
    (1) 1　　　　(2) 2　　　　(3) 0　　　　(4) 4

Name: _____

13. ____ Which nuclear equation represents a natural transmutation?

$$(1)\ {}^{9}_{4}\text{Be} + {}^{1}_{1}\text{H} \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$$

$$(2)\ {}^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \rightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$$

$$(3)\ {}^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + {}^{1}_{1}\text{H}$$

$$(4)\ {}^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\text{He}$$

14. ____ A nuclear fission reaction and a nuclear fusion reaction are similar because both reactions
(1) form heavy nuclides from light nuclides   (3) release a large amount of energy
(2) form light nuclides from heavy nuclides   (4) absorb a large amount of energy

Base your answers to questions 15 and 16 on the information below.
The fossilized remains of a plant were found at a construction site. The fossilized
remains contain $\frac{1}{16}$ the amount of carbon-14 that is present in a living plant.

15. Determine the approximate age of these fossilized remains.

16. Complete the nuclear equation for the decay of C-14. Your response must include the atomic number, the mass number, and the symbol of the missing particle.

$$^{14}_{6}\text{C} \rightarrow {}^{0}_{-1}\text{e} + \underline{\hspace{3cm}}$$
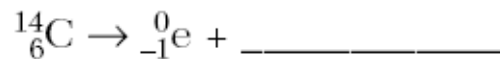
17. ____ Which reaction converts an atom of one element to an atom of another element?
(1) combustion   (2) polymerization   (3) saponification   (4) transmutation

18. ____ Which nuclear emission has the greatest mass?
(1) alpha particle   (2) beta particle   (3) gamma ray   (4) positron

19. ____ Which two radioisotopes have the same decay mode?
(1) ^{37}Ca and ^{53}Fe   (2) ^{220}Fr and ^{60}Co   (3) ^{37}K and ^{42}K   (4) ^{99}Tc and ^{19}Ne

20. ____ Which list of nuclear emissions is arranged in order from the *least* penetrating power to the greatest penetrating power?
(1) alpha particle, beta particle, gamma ray   (3) gamma ray, beta particle, alpha particle
(2) alpha particle, gamma ray, beta particle   (4) beta particle, alpha particle, gamma ray

21. ____ One benefit of nuclear fission reactions is
(1) nuclear reactor meltdowns   (3) biological exposure
(2) storage of waste materials   (4) production of energy

22. ____ Which fraction of an original 20.00-gram sample of nitrogen-16 remains unchanged after 36.0 seconds?

$$(1)\ \frac{1}{5} \qquad\qquad (3)\ \frac{1}{16}$$

$$(2)\ \frac{1}{8} \qquad\qquad (4)\ \frac{1}{32}$$

23. ____ Which radioactive isotope is used in treating cancer?
(1) carbon-14   (2) cobalt-60   (3) lead-206   (4) uranium-238