1. ***Protons*** are positively charged (+) with a mass of 1 amu.
   Example: Which has the greatest nuclear charge? *Cl-35* *Ar-40* *K-39* *Ca-40*

2. ***Neutrons*** have no charge and a mass of 1 amu.

3. ***Electrons*** are small and are negatively charged (-) with a mass of almost 0 amu..

4. Protons & neutrons are in an atom's nucleus (***nucleons***).
   Which has the greatest number of nucleons?
   Sn-119 *Sb-122* *Te-128* *I-127*

5. Electrons are found in "clouds" (***orbitals***) around an atom's nucleus.
   Where is most of the mass of an atom found?
   Where is most of the size (volume) of an atom found?

6. The ***mass number*** is equal to an atom's number of protons and neutrons added together.
   What is the mass number of an atom with 18 protons and 22 neutrons?

7. The ***atomic number*** is equal to the number of protons in the nucleus of an atom.
   Which has the greatest atomic number?
   S *Cl* *Ar* *K*

8. The ***number of neutrons*** = mass number – atomic number.
   Which correctly represents an atom of neon containing 11 neutrons?
   ^{11}Ne ^{21}Ne ^{20}Ne ^{22}Ne

9. In a neutral atom the number of protons = the number of electrons.

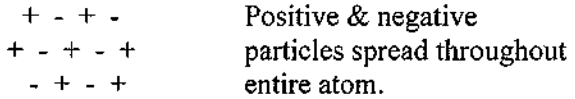
10. ***Isotopes*** are atoms with equal numbers of protons, but differ in their neutron numbers.
    Two isotopes of the same element will have the same number of
    neutrons and electrons, *neutrons and nucleons,*
    protons and nucleons, *protons and electrons*

11. Cations are *positive* (+) ions and form when a neutral atom *loses* electrons.
    They ***are smaller*** than their parent atom.
    Which of the following will form an ion with a smaller radius that that of its atom?
    Cl *N* *Br* *Ba*

12. ***Anions*** are negative ions and form when a neutral atom *gains* electrons.
    They are larger than their parent atom.
    Which electron configuration is correct for a fluoride ion?
    2–7 *2–8* *2–8–1* *2–6*

13. **Ernest *Rutherford's gold foil experiment*** showed that an atom is mostly empty space with a small, dense, positively charged nucleus.

14. ***J.J. Thompson*** discovered the electron and developed the "plum-pudding" model of the atom.



15. ***Dalton's*** model of the atom was a solid sphere of matter that was uniform throughout.

16. The ***Bohr Model*** of the atom placed electrons in "planet-like" orbits around the nucleus of an atom.

17. The current, ***wave-mechanical model*** of the atom has electrons in "clouds" (orbitals) around the nucleus.

18. Electrons can be excited to jump to higher energy levels.
They emit energy as light when they fall from higher energy levels back down to lower (***ground state***) energy levels. ***Bright line spectra*** are produced.

19. ***Elements*** are pure substances composed of atoms with the same atomic number.
They cannot be decomposed.
A compound differs from an element in that a compound

Has a homogeneous composition	*has one set of properties*
Has a heterogeneous composition	*can be decomposed*

20. ***Binary compounds*** are substances made up of only *two* kinds of atoms.
"Ternary" compounds contain three (or more) kinds of atoms.
Which substance is a binary compound?
Ammonia *magnesium* *potassium nitrate* *methanol*

21. ***Diatomic molecules*** are elements that form two atom molecules in their natural form at STP.
Which element is a diatomic liquid at STP?
Chlorine *fluorine* *bromine* *iodine*

22. Use this diagram to help determine the ***number of significant figures*** in a measured value…

Pacific **Atlantic**

If the decimal point is ***present***, start counting digits from the ***Pacific*** (left) side, starting with the first non-zero digit.

0.003100 (….. sig. figs.)

If the decimal point is absent, start counting digits from the Atlantic (right) side, starting with the first non-zero digit.

31,400 (……sig. figs.)

23. When multiplying or dividing measurements, final answer must have as many digits as the measurement with the fewest number of digits.
When adding or subtracting, use place value.
What is the density of the object measured in lab by the displacement of water according to The data below:

Mass of object:	*23.6 g*
Volume of water:	*15.0 mL*
Volume of water + object:	*18.2 mL*

24. ***Solutions*** are the best examples of ***homogeneous mixtures***. They have **two** sets of properties.

25. ***Heterogeneous mixtures*** have discernable components and ***are not*** uniform throughout.
Air is classified chemically as a(n)
Substance *compound* *element* *mixture*

26. A ***solute*** is the substance being dissolved; the ***solvent*** is the substance that dissolves the solute.
NaCl (s) is added to water.
The solute is ..... *the solvent is .....* *the solution is .....*

27. Isotopes are written in a number of ways: C-14 is also Carbon-14, and is also
$^{14}_{6}C$
atomic number = ... *mass number = ...*

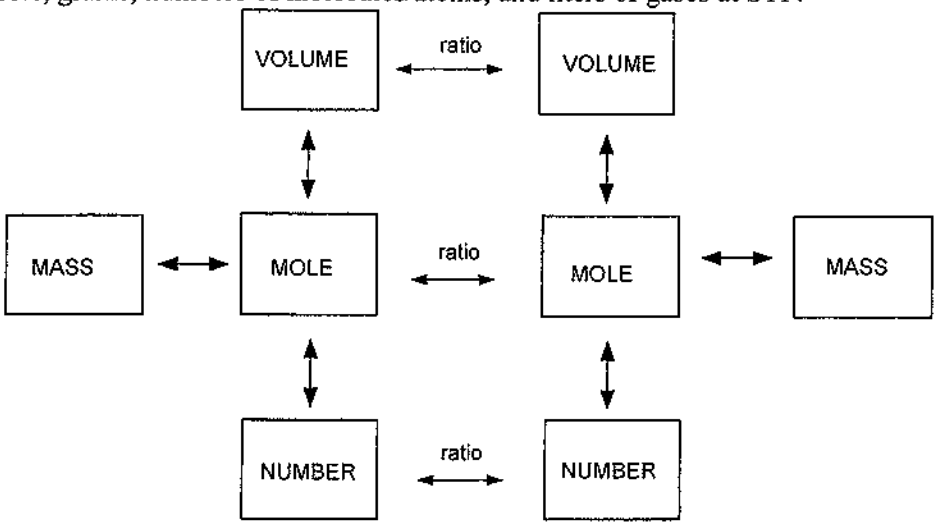
28. The average atomic mass is the weighted average mass of all the known isotopes of an element.
Find the average atomic mass of lithium if 7.4 % are ^{6}Li and 92.6% are ^{7}Li.

29. The distribution of electrons in an atom is its ***electron configuration***.

30. Electron configurations are written in the bottom center of an element's box on the periodic table in your reference tables. The outermost electrons are the valence electrons.

2 = # of electrons in .....
8 = # of electrons in .....
3= # of electrons in .....

31. Use the **mole *map*** to help you solve conversions between moles, grams, numbers of molecules/atoms, and liters of gases at STP.



Given the reaction $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$,
what amount of carbon dioxide is produced by the reaction of 1 mole of CH_4?
1 gram *1 liter* *1 mole* *22 grams*

32. An empirical formula is the simplest mole ratio among the elements in a compound.
Use the mole map to convert percent (mass) to moles.
Find the empirical formula of a compound composed of 75% carbon and 25% hydrogen.

33. ***Electron dot model*** is a way of representing the valence electron of an atom.
 *represents the electron-dot symbol of this element* *C* *O* *B* *N*

34. The ***kernel*** of an atom includes everything in an atom *except* the atom's valence electrons.
The kernel of this element contains 11 protons and 10 electrons
O *F* *Ne* *Na*

35. Polyatomic ions (Table E) are groups of atoms, **covalently** bonded together, with an overall charge.
Nitrate: ……, NH_4^+: ……, sulfite: ……, etc.
Which of the following contains both ionic and covalent bonds?
NaOH *CH_3OH* *NaCl* *Cl_2*

36. ***Coefficients*** are written in front of the formulas of reactants and products to balance chemical equations. They give the ratios of reactants and products in a balanced chemical equation.
……*Na* + ……*Cl_2* → ……*NaCl*

37. Chemical formulas are written so that the charges of cations and anions neutralize (cancel) one another.
calcium phosphate: Ca^{2+} PO_4^{3-} = ……

38. When naming binary ionic compounds, write the name of the positive ion (cation) first, followed by the name of the negative ion (anion) with the name ending in "-ide."
$CaCl_2$ …… *MgS* ……

39. When naming compounds containing polyatomic ions, keep the name of the polyatomic ion the same as it is written in Table E.
NH_4Cl …… *Dimercury (I) nitrate* ……

40. **Roman numerals** are used to show the positive oxidation number of the cation if it has more than one positive oxidation number
FeO: …… *Nickel (III) sulfate:* ……

41. ***Physical changes*** do not form new substances.
They merely change the appearance of the original material. (The melting of ice) H_2O (s) → H_2O (l)

42. ***Chemical changes*** result in the formation of new substances.
Which process is an example of a chemical change?
the melting of ice *the electrolysis of water* *the boiling of water*

43. ***Reactants*** are on the left side of the reaction arrow and ***products*** are on the right.

44. ***Temperature*** is a measure of average kinetic.
Which sample has the highest average kinetic energy?
H_2O (l) at 0°C *H_2O (s) at 0°C* *CO_2 (g) at STP* *Mg (s) at 298K*

45. ***Exothermic reactions*** release energy (energy is a product of the reaction) while ***Endothermic reactions*** absorb energy and the *energy is a reactant* in the reaction.

Given the reaction: $CH_4(g) + 2\ O_2(g) \rightarrow 2\ H_2O(g) + CO_2(g) + heat$
What is the overall result when $CH_4(g)$ burns according to this reaction?
Energy is absorbed and ΔH is negative. *Energy is absorbed and ΔH is positive.*
Energy is released and ΔH is negative. *Energy is released and ΔH is positive.*

46. *Only* coefficients can be changed when balancing chemical equations!
Given the unbalanced equation: $Al + O_2 = Al_2O_3$
When this equation is balanced using the smallest whole numbers, what is the coefficient of Al?
1 *2* *3* *4*

47. ***Synthesis reactions*** occur when two or more reactants combine to form a single product.
$Na_{(s)} + Cl_{2(g)} \rightarrow$ .....

48. ***Decomposition reactions*** occur when a single reactant forms two or more products
$CaCO_{3(s)} \rightarrow CaO_{(s)} +$ .....

49. ***Single replacement reactions*** occur when one element replaces another element in a compound.
Which equation below represents a reaction classified as a "single replacement" reaction?
$2\ H_2 + O_2$ --> $2\ H_2O$
$Pb(NO_3)_2 + K_2CrO_4$ --> $2\ KNO_3 + PbCrO_4$
$HCl + NaOH$ --> $H2O + NaCl$
$Cu + Zn(NO_3)_2$ --> $Zn + Cu(NO_3)_2$
$CaCO_3$ --> $CO_2 + CaO$

50. ***Double replacement reactions*** occur when two compounds react to form two new compounds.
Potassium sulfide is mixed with lead acetate. Which of the following products is expected?
$PbSO_4$ *K_2S* *K_3PO_4* *PbS* *$Pb(C_2H_3O_2)_2$*

51. The masses (and energy and charge) of the reactants in a chemical equation is always equal to the masses (and energy and charge) of the products. ***"Law of Conservation of Mass(and Energy)."***

52. The gram formula mass (molar mass) of a substance is the sum of the atomic masses of all the atoms in it.
H_2SO_4 = ... g/mole
2 x H = 2 x .....g = ...g
1 x S = 1 x .....g = ...g
4 x O = 4 x.....g = ...g

53. Know how to calculate the percentage composition of a compound. (Formula is on Table T.)
Find the percent by mass of oxygen in $CaCO_3$.

54. ***6.02×10^{23}*** is called ***Avogadro's number*** and is the number of particles in ***1 mole*** of a substance.
Equal volumes of gases contain an equal number of molecules.
Under similar conditions, which sample contains the same number of moles of particles as 1 liter of O_2 (g)?
1 L Ne(g) *0.5 L SO_2 (g)* *2 L N_2 (g)* *1 L $H_2O(l)$*

55. Know how to convert an empirical formula into a molecular formula.
A compound has the empirical formula NO_2. Find its molecular formula if the molar mass = 92g.
N_2O *NO_2* *N_2O_4* N_2O

56. The kinetic molecular theory explains the behavior of matter as particles with energy and motion.

57. The particles in a ***solid*** are rigidly held together, closely packed in a **lattice** arrangement.
Which of the following has a regular geometric arrangement at 298 K and 1.0 atm?
Br_2 (l) *CO_2 (g)* *Mg (s)* *H_2O (l)*

58. ***Solids*** have a definite shape and volume.
In what region of the graph below would you only find molecules with definite shape and volume?

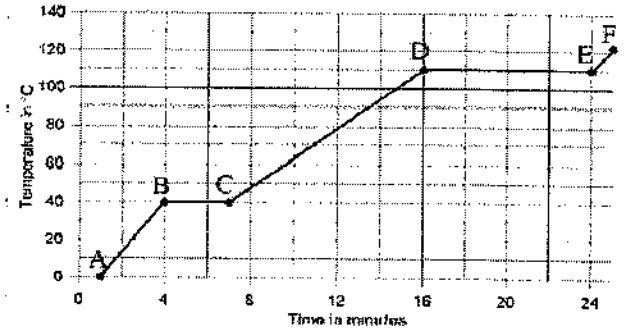
59. ***Liquids*** have closely-spaced particles that easily slide past one another; they have no definite shape, but have a definite volume.

60. ***Gases*** have widely-spaced particles that are in random motion (collide with container to create pressure).

61. ***Gases*** are easily compressed and have no definite shape or volume.
In what region of the graph below would you only find a sample with no definite shape or volume?

62. Be able to read and interpret heating/cooling curves as pictured below.

During which interval on the graph are solid and liquid in equilibrium?



63. Substances that ***sublime*** turn from a solid directly into a gas.
They have very weak attractive forces. (examples include CO_2 & I_2)

64. As they evaporate, liquids become gases, which create vapor pressure. (Reference Table H).
As temperature increases, vapor pressure increases.
*This liquid on Reference Table H has the **weakest** attractive forces:*
Propanone *ethanol* *water* *acetic acid*

65. "***STP***" means "***S***tandard ***T***emperature and ***P***ressure." *Reference Table B*
These conditions define STP *P = ...atm* *T = ...K*

66. Degrees Kelvin = C + 273
Room temperature = 25°C = ...K *Boiling point of helium = 4 K = ...°C*

67. Heat is a transfer of energy from a material at higher temperature to one at lower temperature.
When an ice pack is applied to a bruised arm, ... transfers from ..... to .....

68. Use this formula to calculate heat absorbed/released by substances. $q = mc\Delta t$
q = heat absorbed or released (Joules)
m = mass of substance in grams
c = specific heat capacity of substance (J/gC) ... for water it's 4.18 J/g C.
Δt = temperature change in degrees Celsius
What is the total number of joules of heat energy absorbed by 12 grams of water when it is heated from 30°C to 40°C?

69. The heat absorbed or released when 1 gram of a substance changes between the solid and liquid phases is the substance's ***heat of fusion***. (*Reference Table B*: 334 J/g for water)
How many joules are required to melt 15 g H_2O (s)?

70. The heat absorbed or released when 1 gram of a substance changes between the liquid and gaseous phases is the substance's ***heat of vaporization***. (*Reference Table B:* 2260 J/g for water)
How many joules are required to boil 120 g H_2O (l)?

71. *Always use Kelvins* for temperature when using the ***combined gas law***.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Set up the equation to calculate the volume of 50. mL of methane gas collected at STP when the pressure rises to 2.4 atm and the temperature drops to 240 K.

72. As the ***pressure*** exerted on a gas increases, the ***volume*** decreases proportionally.
25 L of a gas is held at 1.2 atm pressure. Find the new volume if pressure drops to 0.80 atm at constant temperature.

73. As the ***pressure*** on a gas increases, ***temperature*** increases.
A sample of gas exerts a pressure of 220. kPa at 373 K. Find the pressure at 373 K at constant volume.

74. As the ***temperature*** of a gas increases, ***volume*** increases.
15 mL of oxygen gas is collected at 0°C. Find the volume at 50°C at constant pressure.

75. ***Real gas*** particles have volume and are attracted to one another.They don"t always behave like ***ideal gases***. Lighter gases (with weaker attractive forces) are often most ideal.
Which of the following is the most ideal gas?
He *Ne* *Ar* *Kr*

76. Real gases behave more like ideal gases at *low pressures and high temperatures.*

77. Mixtures may be separated by several physical means:
Distillation separates mixtures with different boiling points.
Fractional distillation is a common method to separate and collect
Hydrocarbons *Ionic solids* *Metals* *Precipitates*

Filtration separates mixtures of solids and liquids.
*What would collect **in filter paper** if a mixture of NaCl (aq) and $CaCO_3$ (s) were poured through?*

Chromatography can also be used to separate mixtures of liquids and mixtures of gases.

78. ***The Periodic Law*** states that the properties of elements are periodic functions of their *atomic numbers.*
Elements are arranged on the modern periodic table in order of increasing ……..

79. ***Periods*** are horizontal rows on the Periodic Table.
In which energy level are the valence electrons of the elements in Period 3 found?

80. ***Groups*** are vertical columns on the Periodic Table.
Which group on the periodic table contains a solid, liquid, and gas(es)?

81. ***Metals*** are found left of the "**staircase**" on the Periodic Table and at the bottom, ***nonmetals*** are above it and at the top, and ***metalloids*** border it.
Which of the following Group 14 elements has the greatest metallic character?
Carbon silicon germanium tin

82. Complete and memorize this chart.

Metals	Malleable and ductile	All solids except	Lustrous	Good conductors of heat & electricity	..... ionization energy and electroneg.	Tend to form ..... ions
Nonmetals	Brittle when solid	Mostly gases at STP	Dull	Good insulators	..... ionization energy and electroneg.	Tend to form ..... ions

83. ***Noble gases*** (Group 18) are unreactive and stable due to the fact that their valence level of electrons is completely filled.

84. ***Ionization energy*** increases as you go up and to the right on the Periodic Table.
Which element among the diagrams below has the lowest ionization energy?

85. ***Atomic radii*** *decrease* left to right across a period due to increasing nuclear charge.
Which period 3 element among the diagrams below has the largest radius?

86. ***Atomic radii*** *increase* as you go down a group due to increased electron energy levels.
Which alkali metal among the diagrams below has the largest radius?

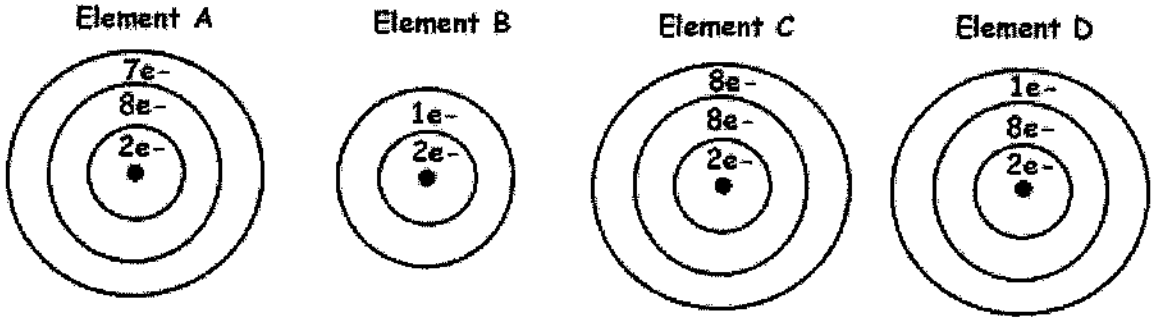
87. ***Electronegativity*** is a measure of an element's attraction for electrons.
Which of the following atoms has the greatest tendency to attract electrons?
calcium carbon copper chlorine

88. Electronegativity *increases* as you go up and to the right on the Periodic Table.
Which element among the diagrams below has the greatest electronegativity?

89. The elements in Group 1 are the ***alkali metals***; those in Group 2 are the ***alkaline earth metals***.
Which atom below represents the alkali metal of period 2?

90. The elements in Group 17 are the ***halogens***.
Which element among the diagrams below is a halogen?

91. The elements in Group 18 are the ***noble gases***.
Which element among the diagrams below is a noble gas?



92. Use ***Table S*** to compare and look up the properties of specific elements.
The freezing point of phosphorus is .....°C

93. Energy is *absorbed* when a chemical bond *breaks*. Energy is *released* when a chemical bond *forms*. The greater the energy, the more stable the bond that forms.
Which of the following, according to Reference Table I, is the most stable compound?
Ethane *ethane* *ethyne* *hydrogen iodide*

94. The last digit of an element's group number is equal to its ***number of valence electrons***.
Which contains the greatest number of valence electrons?
Ca *Ge* *Se* *Kr*

95. Draw one dot for each valence electron when drawing an element's or ion's ***Lewis electron dot diagram***.
Which dot model would contain the fewest dots as valence electrons?
Ca *Ge* *Se* *Kr*

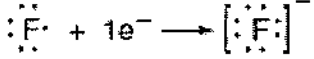
96. **Metallic bonds** can be thought of as a crystalline lattice of kernels surrounded by a "sea" of mobile valence electrons.
Metallic bonding occurs between atoms of
sulfur *sodium fluoride* *sodium* *carbon*

97. Atoms are most stable when they have 8 valence electrons (an ***octet***) and tend to form ions to obtain such a configuration of electrons.
*Which of the following atoms forms a stable ion that does **not** have an octet structure?*
Li *F* *Na* *Cl*

98. ***Covalent bonds*** form when two atoms ***share*** a pair of electrons.
How many covalent bonds are found in a nitrogen (N_2) molecule?

99. ***Ionic bonds*** form when one atom ***transfers*** an electron to another atom when forming a bond with it.
Which substance exhibits ionic bonding rather than covalent bonding?
CO_2 *N_2O_4* *SiO_2* *$CaBr_2$* *$C_6H_{12}O_6$*

100. **Dot models** may be used to represent the formation of ions or covalent molecules.
. Given the equation:



This equation represents the formation of a
fluoride ion, which is smaller in radius than a fluorine atom
fluoride ion, which is larger in radius than a fluorine atom
fluorine atom, which is smaller in radius than a fluoride ion
fluorine atom, which is larger is radius than a fluoride ion

101. ***Nonpolar covalent bonds*** form when two atoms of the *same element* bond together.

102. ***Polar covalent bonds*** form when the electronegativity difference between two bonding atoms is between 0.6 and 1.7.
Which of the following combinations would form a polar covalent bond?
H and H *Na and N* *H and N* *Na and Br*

103. ***Ionic bonds*** form when the electronegativity difference between two bonding atoms is *greater than* 1.7.

104. Substances containing mostly covalent bonds are called ***molecular substances***.
They are attracted to each other by weak van der Waals or stronger hydrogen attractions
Which of the following is a molecular substance?
Lithium chloride *carbon monoxide* *sodium nitrate* *aluminum oxide*

105. **Van der Waals** attractive forces are the attractive force between nonpolar molecules.
Nonpolar molecules are molecules that have structural symmetry.

106. **Van der Waals** attractions become stronger with increasing molar mass.
Which of the following samples has the greatest forces of attraction?
F_2 Cl_2 Br_2 I_2

107. Polar molecules have stronger forces of attraction. The lack structural symmetry.
Which of the following is a polar molecule?
CO_2 H_2O C_4H_{10} N_2

108. ***Hydrogen bonds*** are attractive forces that form when hydrogen bonds to the elements N, O, or F and gives the compound unexpectedly high melting and boiling points.
The strongest forces of attraction occur between molecules of
HCl *HBr* *HF* *HI*

109. Substances containing mostly ionic bonds are called ***ionic compounds***.
They are made of metal and nonmetallic ions. They are held together by electrostatic (ionic) forces.

110. Complete and memorize this table.

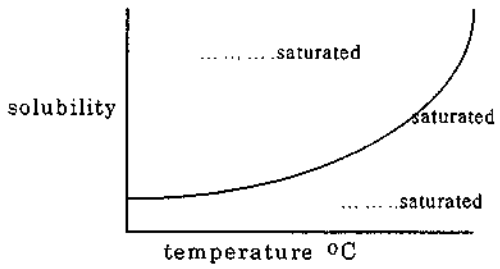
Substance Type	Properties
Ionic	Hard *(Low/high) melting and boiling points* Conduct electricity when molten or aqueous
Covalent (Molecular)	Soft *(Low/high) melting and boiling points* Do not conduct electricity (insulators)

111. Remember: substances tend to be soluble in solvents with similar molecular properties.
"Like dissolves like"
Pentane does not dissolve in water because pentane is …… and water is ……

112. As temperature increases, solubility increases for most solids.
For which solid does increasing temperature have the least effect on solubility?
Potassium nitrate *ammonium chloride* *potassium chlorate* *sodium chloride*

113. At low temperatures and high pressures solubility *increases* for most gases.
*Carbon dioxide gas is **least** soluble in water at conditions of …. temperature and …. pressure.*

114. Use *Table G* to determine whether a solution is ***saturated***, ***unsaturated***, or ***supersaturated***.



115. Use Reference Table F to predict soluble and insoluble products of chemical reactions.
Which compound below would "precipitate" if formed during a double replacement reaction?
$AgNO_3$ K_3PO_4 Na_2CO_3 $MgCl_2$ $CaSO_4$

116. ***Molarity*** is a way to measure the *concentration* of a solution.
Molarity is equal to the number of moles of solute divided by the number of liters of solution. (Reference Table T).
What is the molarity of an NaCl solution if 2.0 mol NaCl is present in 0.50 L solution?

117. ***Percent by mass*** = (mass of the part / mass of the whole) x 100%
A solution of glucose is prepared by added 10. g glucose to 40. g water.
What is its percent composition?

118. ***Parts per million (ppm)*** = (grams of solute / grams of solution) x 1,000,000
A sample of water is found to contain 0.010 g lead in 10. g solution. What is the concentration in ppm?

119. Solutes **raise** the boiling points and **lower** the melting points of solvents.
Which of the following will have the highest boiling point?
1 mol NaCl in 100 g water 1 mole CH_3OH in 100 g water 1mol $CaCl_2$ in 100 g water

120. Liquids ***boil*** when their vapor pressure is equal to the atmospheric pressure. (Reference Table H)
Water will boil at 90°C when the atmospheric pressure is .....kPa.

121. The ***normal boiling point*** of a substance is the temperature at which it boils at 1 atm pressure. (Reference Table H)
What is the normal boiling point of propanone?

122. Chemical reactions occur when reacting species collide effectively.

123. Covalently bonded substances tend to react more slowly than ionic compounds.

124. Increasing the concentration of reactants will increase reaction rate.
Which sample of HCl (aq) will react most rapidly with magnesium metal?
0.50 M HCl 1.0 M HCl 3.0 M HCl 6.0 M HCl

125. Reaction rate increases with an increase in temperature (and pressure for gases).

126. ***Catalysts*** speed up reactions by lowering their ***activation energies***.
They are not changed themselves and can be reused many times over.

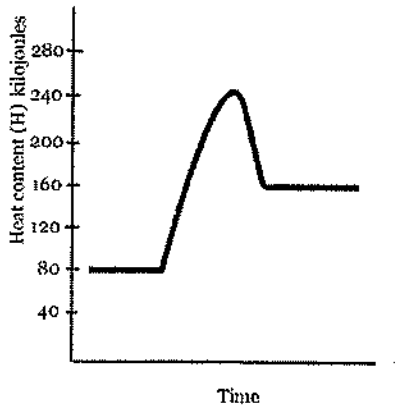
127. Be able to recognize and read ***potential energy diagrams***.
The heat content of the reactants of the forward reaction is about ...kilojoules.

The heat content of the products of the forward reaction is about ...kilojoules.

The heat content of the activated complex of the forward reaction is about ....kilojoules.

The activation energy of the forward reaction is about .....kilojoules.

Add a dotted line to show the effect of a catalyst.



128. The rates of the forward and reverse reactions are equal at equilibrium.
A chemical reaction has reached equilibrium when the
reverse reaction begins
reactants are used up
rates of the forward and reverse reactions are equal
concentrations of products and reactants are equal

129. ***Adding*** any reactant or product to a system at equilibrium will shift the equilibrium away from the added substance.

130. ***Removing*** (taking out) any reactant or product from a system at equilibrium will shift the equilibrium point toward that removed substance.

131. An ***increase in temperature*** shifts an equilibrium system in the ***endothermic direction***.

132. A ***decrease in temperature*** shifts an equilibrium system in the ***exothermic direction***.

133. ***Increasing the pressure*** on a gaseous equilibrium will shift the equilibrium point toward the side with ***fewer moles of gas (less gas volume)***.

134. ***Decreasing the pressure*** on a gaseous equilibrium will shift the equilibrium point toward the side with ***more moles of gas (greater gas volume).***

135. ***Catalysts*** have ***no effect*** on equilibrium. It just establishes itself more quickly.
Given the reaction: $H_2\ (g) + I_2\ (g) <=> 2\ HI\ (g)$
If a catalyst is added, the equilibrium concentration of HI (g) produced .....

136. ***Enthalpy (H)*** is the heat energy gained or lost in a reaction.

137. ***Entropy (S)*** is high in a highly unorganized system, such as a gas, a messy room, etc.
Which of the following has the greatest entropy?
Na (s) $CO_2\ (g)$ $H_2O\ (l)$ $N_2\ (g) + H_2\ (g)$

138. A chemical reaction is most likely to occur (spontaneously) in an exothermic reaction with an increase in entropy.
In the reaction below,
energy ...(increases/decreases)..... and entropy .....(increases/decreases).....
$N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g) + 91.8\ kJ$

139. Oxidation numbers can be assigned to atoms and ions.
What is the oxidation number of S in the sulfate ion?

140. ***Oxidation*** is the ***loss of electrons*** by an atom or ion. The oxidation number *increases* as a result. The electrons are usually on the *right side* of the reaction arrow.
In the reaction $Sn^{+4} + H_2\ (g) \rightarrow Sn^{+2} + 2H^+$, *substance oxidized is*
Sn^{+4} H_2 Sn^{+2} H^+

141. ***Reduction*** is the ***gain of electrons*** by an atom or ion. The oxidation number *decreases* (is reduced!) as a result. The electrons are on the *left* side of the reaction arrow.

142. Redox reactions ***always*** involve the exchange of ***electrons***. Electrons lost = electrons gained.

143. Remember.... OIL RIG **Oxidation is loss of electrons** **Reduction is gain of electrons**
Identify the element that gains electrons in the reaction: 2 Na + Cl_2 → 2 NaCl

144. ***Identify redox reactions*** by looking for changes in oxidation number.
$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
Write the oxidation and half reactions in the above reaction.

145. ***Oxidizing agents*** are what *get reduced* in a redox reaction.
Reducing agents are what *get oxidized* in a redox reaction.
Identify the oxidizing agent in the reaction: $KMnO_4 + HCl + H_2S \rightarrow KCl + MnCl_2 + S + H_2O$

146. Redox reactions can be balanced using the half-reaction method
Balance the equation in #145.

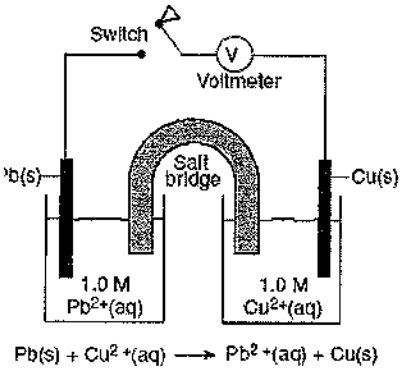
147. ***Electrochemical cells*** produce electricity with a *spontaneous* redox reaction.

In the electrochemical cell shown at the right:

Electrons flow from ..... to .....

The anode is .....; the cathode is .....

.....move through the salt bridge



148. The *left electrode* is *usually* the site of *oxidation* in an electrochemical cell diagram.

149. Memorize this saying... "I have ***AN OX*** and a ***RED CAT***."
In electrochemical cells, the ***AN***ode gets ***OX***idized and ***RED***uction occurs at the ***CAT***hode.
In the chemical cell reaction: Mg + Cu^{2+} → Mg^{2+} + Cu, the anode is .....

150. Use the Activity Series (Table J) to predict whether or not a single replacement reaction will occur.
Which reaction will take place in a 1.0 molar aqueous solution?
Cu + Ag^+ → *Co + Zn^{+2} →* *Ag + Mn^{+2} →* *Sn + Fe^{+2} →*

151. ***Electrolytic cells*** use an applied electrical current to force a nonspontaneous redox reaction to occur.
In what kind of cell are redox reactions made to occur using an externally applied electrical current?
galvanic cell *chemical cell* *electrochemical cell* *electrolytic cell*

152. Electrolytic cells are usually used for metal plating of objects.
When electroplating with silver, the mass of the positive electrode
decreases *increases* *remains the same*

153. ***Acids*** and ***bases*** are both ***good electrolytes***. Their solutions conduct electricity well.
Which of the following is a nonelectrolyte?
LiOH *HBr* *CH_3COOH* *C_2H_5OH*

154. Weak acids taste *sour* and *react with metals.*

155. Weak bases taste *bitter* and *feel slippery.*

156. Acids and bases turn ***indicators*** different colors. They're listed on ***Table M.***
Which solution will change red litmus to blue?
HCl(aq) *NaCl(aq)* *$CH_3OH(aq)$* *NaOH(aq)*

157. pH is the negative log (exponent) of the hydronium [H^+] ion concentration.
What is the pH of a 0.00001 molar HCl solution?
1 *9* *5* *4*

158. Acids have a pH < 7. Bases have a pH > 7.

159. Every 1 pH number **decrease** represents a ten-fold [H^+] **increase.**

160. ***Tables K & L*** list names and formulas of common acids and bases asked about on the Regents.

161. The metals above H_2 on ***Table J*** will react with acids to make H_2 gas bubbles.
Which of the following will react with acid to produce hydrogen gas?
Au *Cu* *Ag* *Zn*

162. ***Arrhenius*** model of acids and bases states:
"Acids give off H^+ to form H_3O^+ ions in aqueous solution as their only (+) ion."
"Bases give off OH^- ions in aqueous solution as their only (-)."
Which of the following is neither an Arrhenius acid nor an Arrhenius base?
KOH *CH_3COOH* *CH_3OH* *HNO_3*

163. ***Brønsted*** model of acids and bases states:
"Acids *donate* protons." "Bases *accept* protons."
Identify one Bronsted acid in the reaction below:
$H_2O + NH_3 \Leftrightarrow NH_4^+ + OH^-$

164. Bronsted acids become Bronsted bases; Bronsted bases become Bronsted acids; forming conjugate pairs.
Identify one conjugate acid-base pair from question #163

165. Acids and bases react in ***neutralization*** reactions to make ***water*** and a ***salt.***
Name the salt produced when sulfuric acid is neutralized by potassium hydroxide.

166. ***Titrations*** are controlled neutralization reactions used to find the concentration of an acid or base sample. Note the formula for it on Table T.
How many mL of a 0.25 M HCl solution are needed to neutralize 20. mL of a 0.40 M NaOH solution?

167. ALL organic compounds contain the element ***carbon and (usually) hydrogen.***
Which of the following is an organic compound?
$CaCO_3$ *KSCN* *CH_3Cl* *CO_2*

168. ***Carbon*** ALWAYS makes ***four covalent bonds*** in molecules.
Which statement explains why the element carbon forms so many compounds?
Carbon atoms combine readily with oxygen.
Carbon atoms have very high electronegativity
Carbon readily forms ionic bonds with other carbon atoms
Carbon readily forms covalent bonds with other carbon atoms

In a molecule of CH_4, the hydrogen atoms are spatially oriented toward the centers of a regular
pyramid *tetrahedron* *square* *rectangle*

169. ***Saturated*** hydrocarbons have all *single* bonds within them (alkanes).
Which compound is a saturated hydrocarbon?
ethane *ethene* *ethyne* *ethanol*

170. ***Unsaturated*** hydrocarbons have *double* or *triple* bonds in them (alkenes & alkynes).
In which pair of hydrocarbons does each compound contain only one double bond per molecule?
C_2H_2 and C_2H_6 *C_2H_2 and C_3H_6* *C_4H_8 and C_2H_4* *C_6H_6 and C_7H_8*

171. ***Hydrocarbons*** contain ONLY the elements hydrogen and carbon.
They are **nonpolar** molecules, **nonelectrolytes,** and do **not** dissolve in water.
172. The ***homologous series*** of hydrocarbons' formulas are on ***Reference Table Q***.

173. The ***functional groups*** on organic molecules are listed on ***Reference Table R***.
Which class of organic compounds can be represented as R -- OH?
acids *alcohols* *esters* *ethers*

174. ***Structural isomers*** of organic compounds have *different* structural formulas but the *same* molecular formula.
Which compounds are isomers?
1-propanol and 2-propanol *methanoic acid and ethanoic acid*
methanol and methanal *ethane and ethanol*

175. ***Number the parent carbon chain*** in an organic molecule from the end closest to the alkyl group(s).
Which molecule contains a total of three carbon atoms?
2-methylpropane *2-methylbutane* *propane* *butane*

176. ***Combustion reactions*** occur when a hydrocarbon reacts with oxygen to make CO_2 and H_2O.

177. ***Organic substitution reactions*** occur when an alkane and a halogen (Group 17) reacts so that one or more hydrogen atoms on the alkane are replaced with the halogen.
What type of reaction is $CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$?
an addition reaction *a substitution reaction*
a saponification reaction *an esterification reaction*

178. ***Organic addition reactions*** occur when an alkene or alkyne combine with a halogen* to make one product (halide).(the double bond between carbons becomes single; triple bond becomes double).
The reaction $CH_2CH_2 + H_2 \rightarrow CH_3CH_3$ is an example of
substitution *addition* *esterification* *fermentation*

179 ***Esterification*** occurs when an organic acid and an alcohol react to make water and an ***ester***.

180. ***Saponification*** occurs when an ester reacts with a base to make alcohol and a ***soap***.

181. ***Fermentation*** reactions occur when yeast catalyze a sugar ($C_6H_{12}O_6$) to make carbon dioxide and ethanol.
The products of the fermentation of sugar are ethanol and
water *oxygen* *carbon dioxide* *sulfur dioxide*

182. ***Polymers*** are long chains of repeating units called ***monomers***.
What substance is made up of monomers joined together in long chains?
ketone *protein* *ester* *acid*

183. Polymers form by ***polymerization*** reactions.

184. ***Addition polymerization*** occurs when unsaturated monomers join in a long polymer chain.
$n(C_2H_2) \rightarrow (C_2H_2)n$

185. ***Condensation polymerization*** occurs when monomers join to form a polymer *by removing water.*
Water is a product!

186. ***Natural polymers*** include starch, cellulose, and proteins.

187. ***Synthetic polymers*** include plastics such as nylon, rayon, and polyester.

188. Unstable atoms that are radioactive are called ***radioisotopes***. (***Table N***)
Which of the following represents a stable nuclide?
Calcium-37 *Potassium-42* *Nitrogen-14* *Phosphorus-32*

189. Each radioactive isotope has a specific mode and rate of decay (half-life).
Which sample will decay least over a period of 30 days? [Refer to Reference Table N]
10 g of Au-198 *10 g of I-131* *10 g of P-32* *10 g of Rn-222*

190. Radioisotopes can decay by giving off any of the particles/emanations listed in ***Table O***.
Which of the following decays by positron emission?
Gold-198 *Neon-19* *Plutonium-239* *Technetium-99*

191. ***Alpha particles*** (see Table J) are positively charged (+).
Beta particles (see Table J) are negatively charged (-). **Neutrons** and **gamma rays** lack charge.
Which particle cannot be accelerated in a magnetic field?
alpha particle *beta particle* *neutron* *proton*

192. The sum of the mass numbers and atomic numbers must be equal on both sides of the reaction arrow for nuclear equations.

$$\begin{array}{ccccc} 18 & & = & & 18 \\ {}^{14}N + {}^{4}He & & & & {}^{17}O + {}^{1}H \\ 9 & & = & & 9 \end{array}$$

193. When radioactive nuclei **decay**, they undergo natural transmutation to form new, stable atoms.
Complete the following decay equation:
$^{232}Th \rightarrow$ ..... + ...

194. When bombarded by radioactive particles, stable atoms undergo artificial transmutation
Identify the element produced when aluminum-27 is bombarded with an alpha particle.
(A neutron is also released).
$^{27}Al + {}^{4}He \rightarrow {}^{1}n +$ .....

195. ***Fission reactions*** split heavy nuclei into smaller ones.
$^{1}n + {}^{235}U \rightarrow {}^{139}Ba + {}^{94}Kr + 3\ {}^{1}n + \text{Energy}$

196. ***Fusion reactions*** occur when light nuclei combine to form a heavy nucleus and *a lot of energy.*
$^{2}H + {}^{2}H \rightarrow {}^{4}He + \text{ENERGY}$

197. The ***half life*** of a radioisotope is the *length of time* it takes for one half of the atoms in a sample to radioactively decay. (Table N) (Table T).

Which sample will decay least over a period of 30 days? [Refer to Reference Table N]

10 g of Au-198 *10 g of I-131* *10 g of P-32* *10 g of Rn-222*

198. Radioactive isotopes have a variety of important uses.

Carbon-14, C-14, is used to determine the ages of organic material up to 23,000 years old.
Uranium-238, U-238, is used to determine the ages of rocks.
Iodine-131, I-131, is used to treat thyroid disorders.
Cobalt-60, Co-60, is used to treat cancer tumors.

199. Radiation can be used to kill bacteria on foods to slow the spoilage process.

200. Disposal of radioactive waste is a problem associated with nuclear reactors